SCIENCE ABSTRACTS

Section A.—PHYSICS.

DECEMBER 1920.

GENERAL PHYSICS.

1511. *Apparatus for the Direct Evaluation of Functions of Two Variables.* **L. Barbillion** and **M. Dugit.** (Comptes Rendus, 171. pp. 389–392, Aug. 17, 1920.)—Instruments with two rectilinear needles, such as the Ferrié-Carpentier wattmeters and frequency meters, provide a practical and convenient means, in certain particular cases, for the direct measurement of a quantity which is a function of two variables. The type of instrument dealt with in the present paper, instead of using two rectilinear needles turning about different axes, employs either two curved needles of a particular shape or one curved and one straight needle turning about a common axis. This results in a considerable reduction in the parallax error. The rotation is limited to angles from 0° to 360°, and the curves (which are arcs of logarithmic spirals), for the curve and straight needle, as the case may be, are arranged so that there is only one point of intersection on the scale. Curved wires have been found to give good results. Examples are given of the application of the instrument (i) for indicating the velocity relative to the air of aircraft, and (ii) for the control of the carburation in explosion motors. **A. W.**

1512. *Longitude Paris–Greenwich by Aeroplane.* **P. Ditisheim.** (Comptes Rendus, 171. pp. 296–298, Aug. 2, 1920.)—The regular air-service between Waddon and Bourget has been utilised for a determination of the difference of longitude between Paris and Greenwich by transport of chronometers. Twelve chronometers were used, rated for 43 days at the National Physical Laboratory, Teddington, as for Class A, the best obtaining the "record" figure of 96·9, the mean being 94·9. Then followed a further 10 days' trial in the horizontal position at a temperature of 18·7° with fixed orientation, subsequently maintained as far as possible. Taken by autocar to Greenwich, they had a week's trial by daily comparisons with chronograph. Special care was taken to keep them level during the air-trips between Waddon and Bourget, and the land journeys were all made by autocar. The mean of 61 operations comes out 9m. 20·947s. ± 0·027s. The probable error is of the same order as those of ordinary telegraphic determinations. The mean of the French and British determinations made in 1902 was 9m. 20·952s., or practically the same as the aeroplane determination. Wireless methods in general supersede this old transport method, but may not always be available. W. W. B.

1513. *Mathematical Examination of Methods of Determining Accuracy of an Observation by Mean Error and by Mean-Square Error.* **R. A. Fisher.** (Roy. Astron. Soc., M.N. 80. pp. 758–770, June, 1920.)—The result of detailed analysis confirms the usual assumption that the mean-square error method is mathematically more exact, the general case yielding a preference of 14 %. Certain classes of observation are, however, suggested wherein the mean error method is on the whole better. W. W. B.

1514. *Adjustment of Observations.* **R. M. Stewart.** (Phil. Mag. 40. pp. 217–227, Aug., 1920.)—Criticises statements made in a previous paper by N. R. Campbell [see Abs. 485 (1920)] with regard to the advantages of the method of zero seen over the method of least squares for the adjustment of observations. The author points out that in many cases the method of least squares is misapplied, and he gives the general solution for all the cases considered by Campbell, including two specific examples. He agrees that a rigorous least-squares solution is sometimes very laborious, and that more approximate methods will often yield results sufficiently accurate for most purposes. J. W. T. W.

1515. *Permeability of Liquid Films to Gases.* **J. C. McLennan** and **W. W. Shaver.** (Phil. Mag. 40. pp. 272–280, Sept., 1920.)—Describes experiments made by means of a Shakespear katharometer, on the permeability of soap-films maintained at constant thickness. The permeability for a thickness corresponding to the red-green stage was found to be 670 litres per sq. m. per day for helium, and 960 litres for hydrogen at 20° C. The permeability for helium was about 70 % of that for hydrogen, practically the same proportion as for the permeabilities to these two gases of balloon fabric. The diffusion of hydrogen through water-films filling the interstices of a wet cotton fabric was found to be very low. A fabric which, when dry, permitted the passage of the gas so readily that no readings with the katharometer were possible, when wetted thoroughly did not allow a detectable diffusion of the gas even when the rate of flow of the air past the fabric was as low as 2·4 litres per hour. J. W. T. W.

1516. *Permeability of Rubber to Gases.* **J. D. Edwards** and **S. F. Pickering.** (Bureau of Standards, Bull. 16. pp. 327–362 [Sci. Papers, No. 387], 1920. Chem. and Met. Eng. 23. pp. 17–21, July 7, and pp. 71–75, July 14, 1920.)—Describes an investigation of the permeability of rubber to a number of different gases. It is found that the permeability of rubber compounds varies with the composition. Ageing, or overvulcanisation is accompanied by a decrease in permeability. Rubber which shows a very low permeability for these reasons is, however, usually very much deteriorated and frequently brittle. The permeability to any gas is found to be directly proportional to its partial pressure, provided the total pressure is constant. The variation of permeability with total pressure depends on the thickness of the rubber and on the way in which it is supported. The permeability to hydrogen is inversely proportional to the thickness of the rubber, the specific permeability for this gas being, at 25° C., and for vulcanised rubber similar to the grade known as dental dam, about 20×10^{-6} cm.^{3} per minute. This value varies somewhat

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with the age and chemical characteristics of the rubber. The temperature coefficient of permeability is quite high, the permeability to hydrogen being about 22 times as great at 100° as at 0° C. The relative permeability of rubber to some common gases is shown in the following table:—

Gas.	Relative Permeability (H = 1).	Gas.	Relative Permeability (H = 1).
Nitrogen	0·16	Hydrogen	1·00
Air	0·22	Carbon dioxide	2·9
Argon	0·26	Ammonia	8·0
Oxygen	0·45	Methyl chloride ...	18·5
Helium	0·65	Ethyl chloride	200

The permeability of rubber to water-vapour is approximately 50 times the permeability to hydrogen. J. W. T. W.

1517. *Regulation of Chronometers.* **J. Andrade.** (Comptes Rendus, 171. pp. 458–461, Aug. 30, 1920.)—Discusses the use of a double spiral spring for the production of a regular sinusoidal vibration.

J. W. T. W.

1518. *Influence of Temperature on the Rigidity of Metals.* **A. Mallock.** (Roy. Soc., Proc. 97. pp. 450–455, Aug. 3, 1920.)—Experiments carried out with a special torsion balance with the object of investigating the effect of temperature on the rigidity of various metals gave no numerical results of sufficient accuracy, but the general conclusions as regards rigidity agree with those previously derived from experiments on Young's modulus [Abs. 666 (1919)], and show that the more infusible the metal the less is rigidity affected by change of temperature. A. W.

1519. *Torsional Elasticity of Nickel Steel Containing a High Content of Chromium.* **P. Chevenard.** (Comptes Rendus, 171. pp. 93–96, July 12, 1920.)—Three series of ferro-nickels have been examined containing respectively 5, 10, and 15 % Cr and, to render the alloys forgeable, up to 1·2 % Mn in the 15 % Cr material. For the alloy with 39·2 % Ni and 10 % Cr the torsional modulus remains practically constant up to 180° C., while the temperature coefficient of this modulus for the alloy with 35·6 % Ni and 9·5 % Cr is almost constant up to nearly 350° C., the value of μ/μ_0 decreasing from 0·9 at 0° to about 0·89 at 300° C. In the region of 12 % Cr the alloy possesses a perfectly constant elasticity over a wide temperature interval. The anomalous dilatation of alloys with C is, as in the case of the pure Fe-Ni alloys, increased by quenching and diminished by cold-working. As the Cr percentage rises so does the temperature at which a rapid falling off of the elasticity sets in. With 15 % Cr this temperature is above 405° C. F. C. T.

1520. *Elastic Properties and the Plastic Extension of Metals.* **W. E. Dalby.** (Roy. Soc. Phil. Trans. 221. pp. 117–138, Sept. 29, 1920.)—When iron or mild steel is overstrained it returns to the perfectly elastic state with remarkable rapidity by mere boiling in water. High-carbon and alloy steels do not recover either by resting for many months or boiling. Reheating to 550° C. caused the entire recovery of elastic properties of an overstrained 3 % Ni steel. The interruption of the tensile test with the removal of the load results, if the metal has been stressed beyond the limits of proportionality, in an unproportional skrinkage rather greater than the previous elastic extension. When the load is reapplied, extension is no longer proportional to the load, and a loop is formed in the stress–strain curve. If this process is continued, each successive loop is slightly greater than the preceding one. This applies to mild, high-carbon and alloy steels. In the case of zinc, copper, and tin there is no true elastic limit, and on the removal of the load shrinkage proceeds for some time under zero load. The relatively slow rate of increase of the area of the loop in the case of copper is noteworthy. An aluminium alloy is of special interest in that the diagrams show no looping. It appears as though the metal continually anneals itself as the plastic stretching proceeds at ordinary temperatures. The area of the loop appears to tend towards a max. value for each material. In iron and mild steels the time factor is of great importance, but the harder steels are comparatively little affected. Even here, however, there appears to be a slight change proceeding during the first few moments after the removal of the load, after which further change is negligible. When stressed under a constant load above the elastic limit a series of loops can be produced which decrease at first and tend towards a constant minimum value. That the limiting fatigue stress has for its positive value the stress equal to the limit of proportionality, is shown in the case of iron. The average value of the limiting fatigue stress for 24,000,000 revs. is 11·75 tons per sq. in., while the limit of proportionality was 11·45 tons per sq. in. F. C. T.

1521. *Number of Alternations in Fatigue Tests.* **K. A. Müllenhoff.** (Stahl u. Eisen, 40. pp. 91–92, Jan. 15, 1920. Rev. de Mét. 17. E. pp. 365–366, Aug., 1920.)—It seems commonly to be assumed that the stress–strain curve would, with a certain stress, become asymptopic to the axis of alternations, but there is no proof for this assumption. The author calls attention to an overlooked paper by O. H. Basquin, of Illinois University, 1910. When the stress is plotted as ordinate against the number of alternations required for fracture on a logarithmic scale, the curves are straight lines showing that stress $\sigma = Cx^n$, where x is the number of alternations. Basquin proved this by data for various steels and copper taken from Wöhler, B. Baker, Reynolds, and Smith, etc. Further investigation is desirable in view also of the parallelity of the curves. H. B.

1522. *Aeroplane Metacentre.* **M. Panetti.** (Accad. Sci. Torino, Atti, 55. 11, 12, 13 and 14. pp. 361–365, 1919–1920.)—A discussion of the precise meaning to be attached to the term "metacentre" in the case of an aeroplane in horizontal flight. It is pointed out that this point must not be confused with the aerodynamic centre. J. W. T. W.

1523. *A Dimensional System of Units with Non-Fractional Exponents.* **R. Ettenreich.** (Phys. Zeits. 21. pp. 404–406, Aug. 1, 1920.)—By the introduction of the fundamental units of energy, quantity of electricity, and length in place of length, mass, and time, a dimensional system is produced in which no fractional exponents occur and which bridges over

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the difference between the electrostatic and electromagnetic systems. In agreement with the relativity theory, space and time, energy and mass have equal dimensions, while velocity appears to be dimensionless. The author proposes to derive the units of this system from the universal constants; velocity of light, mass of the H-atom, electron, and operation quantum. H. H. Ho.

1524. *Geometry of General Dynamics.* **J. Lipka.** (Am. Acad., Proc. 55. pp. 285–322, June, 1920.)—Let U and T be the potential and kinetic energies. The author points out that the problems of determining dynamical trajectories, brachistochrones, and catenaries, and also the paths of light, according to Fermat's principle, in an isotropic medium with a varying refractive index, lead to sets of curves determined by an expression of the form $\int_{P_0}^{P_1} F\,ds = \text{minimum}$, where F is a function of the coordinates of position only, and ds is the element of length in the space considered, so that each set forms what Painlevé calls a natural family. There will be only one such family in the optical case, but in the other three cases there will be ∞^1 such families corresponding to all possible values of the energy constant. In a system with n degrees of freedom there will be n independent position coordinates $x_1, \ldots x_n$, and where T is the kinetic energy, $2T = \sum_{ik} dx_i/dt\,.\,/dx_k/dt$ $(i, k=1, 2, \ldots n)$, where the a's are functions of the n x's. If the acting forces are conservative, there will exist a work function $W(x_1, \ldots x_n)$ independent of the time, and $h = T - W$, so that the trajectories will be given by

$$\int_{P_0}^{P_1} \sqrt{2(W + h)}\ \sqrt{\sum_{ik} a_{ik}\,dx_i\,dx_k} = \text{minimum}.$$

Taking P_0 and P_1 as two points in a space of n dimensions, $x_1 \ldots x_n$, may be taken as the coordinates of a point in this space, the element of arc will be given by $ds^2 = \sum_{ik} a_{ik}\,dx_i\,dx_k$, and the problem becomes one of minimising $\int F\,ds$ where F is a function of $x_1 \ldots x_n$ and ds is the arc element in a space of n dimensions, which may be of zero, constant, or variable curvature. The natural family then consists of $\infty^{2(n-1)}$ curves, one through each point in each direction. If $W = 0$, $F = \text{constant}$, and the problem reduces to finding the curves for which $\int_{P_0}^{P_1} ds = \text{minimum}$, which evidently defines the geodesics. Now in 1869, E. Beltrami [Acad. Sci. Bologna, Ser. 2a. Vol. 8. p. 549] proved the following theorem, a generalisation of Gauss's theorem for the geodesics on an ordinary surface: *The ∞^{n-1} geodesics which pass out normally from points of any hypersurface V_{n-1} form a normal hypercongruence, i.e., one which admits ∞^1 normal hypersurfaces, which are the loci of equal arc lengths measured from any one of the system of hypersurfaces.* In 1871, R. Lipschitz [Crelle, Vol. 74] obtained the corresponding theorem for the general problem of dynamics, the statement of which may be derived by replacing the words *equal arc lengths* in Beltrami's theorem by *equal values of $\int F\,ds$*, which is true for space of any dimensions or any curvature. Thomson and Tait had given this theorem for dynamical trajectories in a conservative field of force in euclidean space of three dimensions in the form :—" If from all points on an arbitrary surface, particles not mutually influencing one another be projected with the proper velocities [so as to make the sum of the kinetic and potential energies have a given value] in the direction of the normals; points which they reach with equal actions lie on a surface cutting the paths at right angles." The ∞^1 orthogonal surfaces appear as surfaces of equal action. A similar theorem may be stated using the language of brachistochrones, or of optical light-paths; in these cases the ∞^1 orthogonal surfaces appear as surfaces of equal time. The question then arises whether the orthogonal property belongs exclusively to natural families of curves, and receives a complete affirmative answer in the present paper, resulting in the theorem: If a system of $\infty^{2(n-1)}$ curves in space of n dimensions, euclidean or curved, is such that ∞^{n-1} curves of the system meet an arbitrary hypersurface orthogonally, and always form a normal hypercongruence, the system is of the natural type. This converse of the Lipschitz theorem was proved for three-dimensional spaces of constant curvative by E. Kasner (Am. Math. Soc. Trans. 11. pp. 121–140, 1910). The author proves it (1) for a four-dimensional Euclidean space (2) for an n-dimensional Euclidean space, (3) for an n-dimensional curved space. These steps are preceded by sections dealing with:—Distance and angle in a space V_n; a derivation of the differential equations of the natural family of curves by the variational method: a simple direct proof of the Lipschitz theorem: the conditions for a normal hypercongruence: the analytic statement of the converse theorem.

G. W. DE T.

1525. *Static Friction.* II. **W. B. Hardy.** (Phil. Mag. 40. pp. 201–210, Aug., 1920.)—Section A deals with the chemical constitution and lubrication of bismuth. The experiments described are a continuation of earlier work on the static friction of glass surfaces [Abs. 1142 (1919)]. A slider having a curved surface was applied to a plane surface, both slider and plate being of bismuth. This metal was chosen because it is highly crystalline, and at the same time takes a high degree of polish. It therefore offered unusual facilities for comparing the friction of the amorphous state of the metal found on a burnished face [see Abs. 1875 (1904)], with that of the crystalline state. Profuse experimental details are given, and the test of surface cleanliness is defined in terms of static friction, namely: that surfaces are clean when static friction is a maximum, *i.e.*, where it reaches a certain amount, which is reduced by every substance applied to the surface. Many substances are neutral to glass in that they do not alter the static friction, but no substance neutral to bismuth was found. A few lubricants appear to abolish the static friction of bismuth altogether; *e.g.* ricinolic acid. Static friction is found to be a function of the molecular weight of the lubricant, and in a simple chemical series of chain compounds such as fatty acids and alcohols or paraffins, a good lubricant will be found if we go high enough in the series. It is not a simple function, however, and the influence of molecular weight is overshadowed by the influence of chemical constitution. In some chemical series the relation appears to be a linear one; *e.g.*, the paraffins and benzene-naphthalene-anthracene. In the aliphatic alcohols and acids, the chain is weighted at one end with the $-OH$ or $-COOH$ group, and the simple linear relation to molecular weight is disturbed thereby. The relation of lubricating qualities to viscosity broadly resembles that to molecular weight, but no fundamental relationship exists between them. Fluidity of the lubricant has no constant significance, as indeed might be expected on the surface-energy theory of lubrication. In their qualities as lubricants of bismuth, ring compounds are the converse of chain compounds: thus the effect of a double-bonded atom is to decrease the lubricating value of the former, and to increase that of the latter. The more saturated *cyclo*-hexane and its derivative are better lubricants than benzene. When ring and chain are joined as in butylxylene, the result is a better lubricant than either. When the atoms are disposed with complete symmetry about a carbon atom, the result is a very bad lubricant; *e.g.*, CCl_4 and $C(CH_2OH)_4$. In ring compounds the replacement of hydrogen decreases lubricating power in the case of N, O, or $-COOH$, and increases it in the case of other groups in the order $C_2H_5 < CH_3 < OH$. The more simple a second substituted group is the more effective it is. The esters occupy a quite unexpected position. The simple aliphatic esters are much worse lubricants than their related acids or alcohols, while the ring esters are better. Perhaps the most interesting substances are the hydroxy acids, with OH and COOH groups. This conjunction produces a remarkable increase in the lubricating power of a chain compound (*e.g.*, α-lactic and ricinolic acids), and almost destroys it for ring compounds (*e.g.*, salicylic and benzylic acids). No ring compound is a good lubricant. A table is given showing quantitative results for a large number of compounds.

In 1903, Beilby described how, in the process of burnishing or polishing, the substance of the solid actually flows so as to cover the surface with a film of amorphous material. Section B of the paper deals with the influence of this Beilby film on bismuth.

Section C considers the adsorption of lubricants. It has previously been shown that the capacity for decreasing friction is a function of the potential of the attractive forces between lubricant and solid integrated through the depth of the layer, whilst the stability of a layer of a given thickness is a function of the differential coefficients of the interfacial energy taken with reference to the thickness. The integral is the work done by the cohesive forces acting between lubricant and solid, when the layer of the former is interposed between the faces of the latter. This is now expressed in terms of a tension, and thereby becomes measurable if one solid face alone is considered. Direct evidence is given to show that the forces of attraction operate more strongly between a solid face and a good lubricant than between it and a bad one. The better lubricant is more strongly adsorbed by the solid face, a result used for removing olefines from impure paraffin; the better lubricants, namely, the olefines, being absorbed when the commercial paraffin is filtered through a dry powder.

H. H. Ho.

1526. *Growth of Waves.* **A. Mallock.** (Nature, 105. p. 777, Aug. 19, 1920.)—There has always been some difficulty in accounting for the growth of waves under the action of wind. The author believes that the true explanation is that the waves do not increase in length unless they are breaking. Some rough observations have been made on a pond about 1000 ft. long. It was found that in a brisk breeze the waves formed at the windward end showed as ripples a few inches long, while at or near the leeward margin the wave-length was about two feet. If it is assumed that the wave-length increased regularly, there would be about a thousand crests in the length of the pond, and the gain in length from wave

to wave would be about one-thousandth of the mean wave-length. All the waves from the least to the greatest were in a breaking condition. The ripples did not show any foam at their crests, but it was clear from their shape that they were actually breaking. It is suggested that experiments on the subject might be carried out, say, in the Froude tank.
E. H. B.

1527. *Pressure in a Viscous Liquid moving through a Channel with Diverging Boundaries.* **W. J. Harrison.** (Cambridge Phil. Soc., Proc. 19. pp. 307–312, Feb., 1920.)—Mathematical.

1528. *Pressure Distribution on the Head of a Shell moving at High Velocities.* **L. Bairstow, R. H. Fowler,** and **D. R. Hartree.** (Roy. Soc., Proc. 97. pp. 202–218, May 1, 1920.)—A description of experiments in which the fuse is used as a manometer to measure the pressure under which the powder is burning.
L. H. W.

1529. *Stability of Rectilinear Vortices of Compressible Fluid.* **B. Datta.** (Phil. Mag. 40. pp. 138–148, July, 1920.)—Mathematical treatment with four cases worked out in illustration of the author's procedure.
L. H. W.

1530. *End Correction in determination of Gas Viscosity by the Capillary Tube Method.* **W. J. Fisher.** (Phys. Rev. 16. pp. 83–84, July, 1920.)

1531. *Gravitation and Relativity.* **C. W. Kanolt.** (Frank. Inst., J. 190. pp. 211–242, Aug., 1920.)—A condensed general treatment of the subject expressed as far as possible in non-mathematical language.
L. H. W.

1532. *Crystal Structure of Sodium Nitrate.* **R. W. G. Wyckoff.** (Phys. Rev. 16. pp. 149–157, Aug., 1920.)—*The crystal structure of sodium nitrate* has been determined from a study of the Laue photographs obtained by passing X-rays through crystal sections. The *method of interpretation* is similar to that used by Nishikawa in studying spinel.

The unit rhombohedron of sodium nitrate is a body-centred structure containing two molecules of $NaNO_3$. The marshalling of the atoms in the crystal as a whole resembles that within a crystal of sodium chloride with NO_3 groups replacing the chlorine atoms of NaCl. AUTHOR.

1533. *Atomic Structure and Crystal Symmetry.* **H. Thirring.** (Phys. Zeits. 21. pp. 281–288, June 1, 1920.)—In addition to the fact that the intensity of reflection of X-rays at the network of planes in a crystal depends only on the number of electrons per unit area, but not on the orientation of the atoms, it must also be considered that the length of the side of the elementary cube of the "atom grating" is a whole-number multiple of each ot the appertaining "point gratings." This latter condition is a consequence of the resulting X-ray analysis of the crystal under observation. In view of these conditions the author makes the following deductions from considerations of symmetry:—(1) The carbon atom has no "cylinder-symmetry," and therefore has not a plane Bohr-electron ring system. Also systems with crossed electron rings cannot be brought into harmony with the symmetry of the diamond; on the contrary, this is the case for the arrangement with tetrahedral symmetry of the electron orbits as suggested by Landé. (2) The explanation given by Bragg for the hemihedral structure of KCl, in which the atoms do not lie exactly at the corners of the cube or the face-centres, but have positions somewhat displaced therefrom, follows from the completely determined arrangement for $n = 2$. (3) It is not possible to construct a KCl grating with regular enantiomorphous symmetry for axial symmetrical atoms (plane ring models), if we retain the assumption that no K- or Cl-atom can be placed in front of another K- or Cl-atom respectively. (4) With Landé's atom model the hemihedral structure of KCl can be explained by taking $n \geqq 2$, if we assume that the magnetic forces produced by the K-atom play a part in determining the symmetry properties of the crystal. (5) From the holohedral structure of NaCl it follows on other grounds that these magnetic forces of the alkali-atoms in the vertical series of the periodic system so increase, that in Na they are hardly noticeable, whilst in calcium they can exert an influence on the crystal symmetry. A. B. W.

1534. *Surface Tension and Electric Conductivity at Extreme Temperatures.* **F. M. Jaeger.** (Engineering, 110. p. 437, Oct. 1, 1920. Paper read before the British Assoc., Cardiff, Aug., 1920.)—A summary of the author's work at temperatures from −100° up to +1600° [Abs. 829 (1919)]. The conductivity-determinations have not been carried far yet owing to the difficulties of insulation at high temperatures. Some salts, including potassium tungstate and molybdate, gave straight lines up to 1625,° indicating a simple structure of these salts. H. B.

1535. *Thickness of Stratified Films.* **P. V. Wells.** (Engineering, 110. pp. 383–384, Sept. 17, 1920. Paper read before the British Assoc., Cardiff, Aug., 1920.)—Measurements were made on films of aqueous solutions of potassium oleate in various concentrations, of glycerin and of uranin. Films of these solutions appear in the first instance white, but in intense agitation; they develop coloured spots and fringes, bordered in irregular fashion like the contour lines of maps; then a few black spots of thinnest and most stable film appear and spread, leaving the other liquid in the shape of droplets and also in fibrous channels, in which a lively circulation continues. The thickness of the black film found by Wells for oleate and for glycerin is about 4×10^{-7} cm.; with Perrin he regards the film as bimolecular, each layer of pure oleic acid having a thickness of about $1 \cdot 9 \times 10^{-7}$ cm. (Perrin), whilst Langmuir considers the thinnest films (oil films on water) as monomolecular and of thickness $2 \cdot 3 \times 10^{-7}$ cm. The oleates will spread on a water surface because they contain the active COOH group which is soluble in water and is characterised by a double bond, whilst the insoluble pure hydrocarbons do not spread. A. W.

1536. *Surface Tension and Dielectric Constant.* **T. Takeuchi.** (Phys. Math. Soc. Japan, Proc. 2. pp. 192–194, Sept., 1920.)—Laplace's classical work on surface tension did not introduce the law of attraction between molecules, but later scientists have attempted to deduce the exact law of molecular attraction and the molecular constitution of the free surface in their relation to chemical affinity. No consistent results, however, have been obtained. To obtain an idea of the nature of the attraction, a decision as to its electrostatic or electromagnetic character is fundamental. If the former, then surface tension must be inversely proportional to the dielectric constant; if the latter, it must be inversely proportional to the permeability and therefore directly to the dielectric constant. The author has tabulated the values of the surface tension and dielectric constant for infinitely great wave-length, for a number of substances, *e.g.*, petroleum, carbon tetrachloride, benzene, etc., and infers that the attraction must be essentially electromagnetic for a number of these. The paper concludes with an approximate deduction of the Eötvös formula from Kleeman's extension of Einstein's deduction.

Further work on these lines is promised. H. H. Ho.

1537. *Viscosity of Colloidal Solutions.* **P. Bary.** (Comptes Rendus, 170. pp. 1388–1390, June 7, 1920.)—The viscosity of liquids holding solid matter in suspension may be calculated by Einstein's formula, $\eta = \eta_0(1 + 2\cdot5v)$, in which η and η_0 are the viscosities of the suspension and pure medium respectively, and v the volume of matter dispersed per unit volume. Experiment has shown that this formula is applicable when the dispersed substance has not absorbed the liquid of the medium, *i.e.*, when the volume v is the real volume of the granules. On the other hand it is inapplicable to colloids which absorb liquid. The author proposes to utilise viscosity measurements for calculating the swelling of suspension colloids, instead of applying the above formula for viscosity determination. From the results obtained certain deductions are drawn as to the constitution of these suspensions.

When unit volume of dry colloid swells by a volume a of liquid, $v = v_0(1 + a)$, and Einstein's formula becomes $\eta = \eta_0[1 + 2\cdot5v_0(1 + a)]$, from which $a = (\eta - 1 - 2\cdot5v_0)/2\cdot5v_0$ when η_0 is taken as unity. Consequently the coefficient of swelling may be calculated when the concentration and viscosity referred to the pure medium are known. The determination of a for such colloidal solutions as gelatin, night blue, and benzopurpurin in water, india-rubber in benzene, and nitrocellulose in acetone, shows the coefficient of swelling to diminish, on the one hand, with the age of the suspension, but within a limiting value, and on the other hand with the degree of dilution. For all these suspensions except gelatin, the swelling tends towards zero for infinite dilution. This result may be explained by the fact that these bodies which are highly polymerised in the solid state, are associated more and more with dilution, and tend to the simple molecular state as the concentration approaches zero. The case of gelatin is more complex, inasmuch as, contrary to the other colloids mentioned, it is not peptonised by water alone at ordinary temperatures, but simply swells and is transformed into a jelly. The latter cannot be split up at ordinary temperatures into smaller granules, but when treated with hot water becomes two products, α and β, which differ in their ability to coagulate. The author has calculated the swelling which these bodies undergo in suspensions from viscosity data by Levitès. He finds α to possess a value of 14 at 35° C. at the greater dilutions, and that this increases with concentration. Gelatin β appears to possess a constant value of 7·5 whatever the concentration, and would seem to be a depolymerised product which contains a constant amount of water of absorption or combination at 35° C.

From this preliminary study the author concludes that colloids which become suspensions in a medium without the aid of any other agent, furnish liquids whose particles subside progressively with time to a degree dependent on concentration and temperature The swelling tends towards zero for zero concentration. This result is in accord with ultramicro-

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scopic observations which show that the magnitude of the granules augments with concentration due to polymerisation, and so increases their colloidal properties. H. H. Ho.

1538. *Mechanics of the Glacial Anticyclone illustrated by Experiment.* **W. H. Hobbs.** (Nature, 105. pp. 644–645, July 22, 1920.)—The author holds that a domed surface of the ice is necessary for the development of the glacial anticyclone and the alternating calms and blizzards associated with it. Air in contact with the surface is cooled and removed to lower levels under the action of gravity and a further supply must be drawn down from higher levels to replace it. The note describes apparatus in which this action is illustrated (1) by water flowing down the sides of a cooled copper dome immersed in it, the motion of the water being made visible by initially colouring the surface layers, (2) by air flowing down a cooled metal dome, smoke being used to demonstrate the currents. The air descends under gravity and is therefore slow in starting, later attaining high velocities, but in Nature the motions are modified by adiabatic changes, and, moisture being involved, by transformation of sensible and latent heat. The initially quiet state of the atmosphere promotes the cooling of the air, and the blizzard, having developed gradually, is stopped somewhat suddenly when the adiabatic changes during descent have overcome the initial cooling. When the blizzard is accompanied by snow the latent heat released aids this effect. M. A. G.

1539. *Relation between the Absorption of Solar Radiation by the Atmosphere and the Polarisation of Diffuse Sky Light.* **A. Boutaric.** (J. de Physique, 9. pp. 239–256, July, 1920.)—Finds that corresponding to an increase in the absorption of solar radiation by the atmosphere there is a corresponding decrease in the proportion of diffuse sky light polarised. The result is based on observations made at Montpellier on cloudless days, using the compensation pyrheliometer of K. Ångström and a Cornu polarimeter. Observations of humidity at the surface were also made on the same days. The portion of the sky chosen for the polarimetric observations was that 90° from the sun in the same vertical circle, this being the region of max. polarisation. The result was verified for observations (1) on the same day, comparing observations at times symmetrically placed with respect to noon; (2) on days close together, comparing observations at the same hour of the day; (3) on days belonging to different months, comparing observations at times corresponding to an equal thickness of atmosphere traversed by the solar radiation; (4) for corresponding days of different years. If on two occasions the conditions as to humidity are very different there may be an apparent exception, since this affects the observed intensity of radiation, but not the polarisation. Further, in (3) a small correction is necessary for the effect on the intensity of radiation of the varying distance of the earth from the sun. It is suggested that there is a relation appropriate to a given station and possibly the same for all stations of the same altitude, of the form $I = f(d, t, P, f)$, where I is the intensity of solar radiation received at the earth's surface, d the distance of the sun from the earth, t the thickness of atmosphere traversed by the solar radiation, P the polarisation, and f the vapour pressure in the air. t and P are of greater importance than d and f. In a further part the relation between absorption of direct and polarisation of scattered radiation, is studied as a laboratory experiment. M. A. G.

1540. *Potential Gradient and Thunderstorm Forecasting.* **A. Hölzel.** (Ann. d Physik, 60. 6. pp. 521–547, Nov. 27, 1919. Dissertation, Leipzig.) —Records of potential gradient and thunderstorms at Leipzig are examined with a view to determining whether any useful warning of the approach or formation of a thunderstorm may be obtained from observations of potential gradient. The records extend over the period Jan. 1913 to July 1914 inclusive. The first disturbance of the potential gradient, associated with 17 storms which passed over the station, preceded the first rain (taken as indicating the arrival of the storm) by periods ranging from 3 to 109 minutes and averaging 46 mins. In 6 cases the rate of travel of the storm was known, the average being 33 km./hour, yielding an average distance at the time of the first disturbance of the gradient, of 33 km. Of storms which passed at a distance from the station, some were associated with rain at the station and others not. Of the former, the first disturbance of the gradient preceded the rain by intervals ranging from 0 to 42 mins. From the forecasting point of view, however, the first disturbance of the gradient by a thunderstorm cannot be distinguished from disturbances due to minor causes. The author goes on to consider the time at which the gradient has reached a certain value as a criterion of the approach of a storm, and reaches the conclusion that it is within the bounds of possibility to receive a warning of half an hour to one hour by observations of the potential gradient considered in relation to its normal course. This warning will usually precede the first thunder heard. The instruments used at Leipzig are described, and the mean diurnal variation of potential gradient for each month and the seasonal variation for the period Jan. 1913 to July 1914, are included in the paper. M. A. G.

1541. *Temperature Variations at* 10,000 *ft.* **C. K. M. Douglas.** (Nature, 105. p. 614, July 15, 1920.)—Five hundred observations of temperature and pressure made during aeroplane ascents in N.E. France in 1918–19 gave a correlation coefficient 0·73, and if seasonal variation is allowed for, a coefficient 0·69. This last coefficient implies that 72 % of the standard deviation is still unaccounted for. The partial correlation coefficient between temperature and southerly component of wind at 10,000 ft. (allowing for the pressure) is 0·44, the southerly component thus accounting for 7 % of the total variations of temperature and 10 % of those independent of pressure. The effect of the westerly component is negligible. The author believes that a large proportion of the temperature variations depends upon the original polar or equatorial source of the air supply, but that this is not shown in the correlation with the south component of the wind velocity, since both polar and equatorial currents may follow curved paths. A paper on the subject is promised. M. A. G.

1542. *Local Weather Conditions at Mullion, Cornwall.* **N. L. Silvester.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 246–269; Disc., 269–270, July, 1920.)—Observations, instrumental and otherwise, made at the Air Station, Mullion, from about July 1916 to Oct. 1917 are discussed in very great detail. In the analysis of the anemobiagrams special attention is devoted to those features of importance to pilots of lighter-than-air craft, the max. gust being considered, for example, rather than the mean velocity. Minimum gustiness is found for winds with a southerly component and maximum with a northerly. The relation between the surface and gradient wind is set out for each wind direction, and for morning, noon, and evening. Fog and mist are classified as (1) radiation fog, which occurs at all seasons but mainly in summer; (2) sea fog, entirely restricted to summer months, and most frequent during May; (3) coast mist and drizzle, occurring, with few exceptions, with winds having a southerly component and at all seasons. Conditions do not favour summer thunderstorms, though a thundery tendency is apt to develop with a shallow depression over the Bay of Biscay, or passing up the Channel. The winter type of thunderstorm, however, frequently passes over the station. A very complete table gives local signs of approaching depressions—for instance, unusual visibility, which as a rule precedes the first appearance of cirrus. 52 % of depressions recorded were preceded by this phenomenon. Of the recorded cases of unusual visibility only 20 % were not followed, within 48 hours, by a wind exceeding 24 miles/hr., and only 16 % were not followed by rain within the same period. Close observation of sunrise and sunset skies seem to indicate that brilliant skies are precursors of windy weather. The paper contains many more local details.

M. A. G.

1543. *Practical Weather Forecasting.* **L. Dunoyer** and **G. Reboul.** (Comptes Rendus, 170. pp. 1275–1277, May 25, 1920.)—Various rules, used during the war, for forecasting from synoptic charts have already been described, and the degree of success likely to be obtained by the use of each rule is discussed [see Abs. 997 (1919)]. None of these rules alone gives a "coefficient of probability" above 0·7 or 0·8. A systematic method of applying the ensemble of rules to a particular chart is now outlined. The points shown on the chart, *e.g.*, barometric tendencies, force, and direction of surface and upper winds, temperatures, etc., to which the rules are applicable, are tabulated together with the modification of the situation which is indicated by each. Concordant results may then be obtained by several different rules, and a forecast based on the table will not only have a greater likelihood of success than one based on a single rule, but in all cases an estimate of the probability of success of the forecast may be made, taking into account the coefficient of probability of each rule used. M. A. G.

1544. *Constant-Elevation Free-Balloon Flights from Fort Omaha.* **C. L. Meisinger.** (Monthly Weather Rev. 47. pp. 535–538, Aug., 1919.)—By means of two free-balloons from Fort Omaha, Nebr., sailing at constant elevations of 5000 and 10,000 ft. respectively, it was possible to determine with fair accuracy the trajectory of an air particle in the given pressure distribution. The upper balloon was able to maintain its elevation much more satisfactorily than the lower, because of its comparative freedom from the effects of the Ozark Mountains. A comparison of the actual speeds of the balloons with the computed wind speed or gradient wind shows that the lower balloon, especially during the smoothness of the night, averaged within 0·5 m. per sec. of the computed speed. The paths of both balloons were practically the same, showing that the effect of the controlling cyclone, the centre of which was over the Great Lakes, persisted to a considerable height. The speed of the upper balloon was slightly greater than that of the lower. AUTHOR.

1545. *Convection Currents in the Atmosphere in their Relation to Certain Forms of Clouds.* **P. Idrac.** (Comptes Rendus, 171. pp. 42–44, July 5, 1920.)—In opposition to the atmospheric wave theory of the cause of parallel cirrus bands, the author suggests that they may be due to vortices in the atmosphere with horizontal axes, arising out of the relative motion of adjacent layers of air of different temperature. This is based on a laboratory experiment, and admits of a test, for the experiment shows that the axes, and hence the cirrus bands, should be parallel to the relative velocity of the adjacent layers of air (or the vertical gradient of wind velocity), while the wave theory, on the other hand, demands that the bands of cloud should run perpendicular to this. Some observational data are produced, which lend support to the author's view as opposed to that of wave motion. M. A. G.

1546. *Apparent Form of the Dome of the Sky.* **H. Dember** and **M. Uibe.** (Sächs. Gesell. d. Wissenschaften, Leipzig, Ber. Vol. 69. July 31, 1917. Ann. d. Physik, 61. 4. pp. 313–333, Feb. 22, 1920. Abstract.) —Further to Abs. 1147 (1918).

1547. *Clouds as seen from an Aeroplane.* **C. K. M. Douglas.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 234–242, July, 1920.)—Photographs with descriptive text. L. H. W.

1548. *Evolution of the Snow Crystal.* **J. C. Shedd.** (Monthly Weather Rev. 47. pp. 691–694, Oct., 1919.)—Photographic reproductions of 200 forms of crystal are included. L. H. W.

1549. *The Figure of the Earth.* **O. Z. Bianco.** (Accad. Sci. Torino, Atti, 55. pp. 118–131, 1919–1920.)—A useful critical *résumé* of the work of Airy, Darwin, Hargrave, Bruns, Wiechert, Helmert, Clairaut, Callandreau, and Hamy. A. D.

1550. *High Rates of Ascent of Pilot-Balloons.* **W. van Bemmelen.** (Nature, 105. pp. 485–486, June 17, 1920.)—Wenger [Annalen der Hydrographie, 1917, Hamburg] suggests that high rates of ascent shown by pilot-balloons are not, as is commonly held, mainly due to ascending air currents, but that the influence of increased turbulence of the air preponderates in producing the effect, asserting that the rate of ascent depends on the condition of the air as to wind, friction, etc. The author, in three very complete sets of observations made at all times of the day and night at Batavia, Bandung, and on a small coral islet in the Java Sea, finds support for the commoner view. A diagram, giving for different periods of the day the digression of the mean rate of ascent at heights below 3 km. from that at 3 or 4 km., shows for Batavia and Bandung, where insolation is powerful, a large positive digression in the first km. during the day, greatest after noon, and absent at night. On the island, where insolation is negligible, no such digression is found at all. This might not at first sight appear inconsistent with Wenger's view, but the rate of ascent is not found to depend on the wind velocity, and indeed a wind velocity exceeding 15 m./sec., necessary according to Wenger to produce a materially increased turbulence, was not often observed. Further, the increase of turbulence due to insolation is expected to be greatest before noon, owing to increasing cloud later in the day; the greatest digressions are, however, observed after noon. While both effects may be active, the author is led to regard the commoner view as tenable rather than Wenger's view. M. A. G.

1551. *Frequency of Fog in the Eastern Sahara.* **J. Tilho.** (Comptes Rendus, 170. pp. 1435–1438, June 14, 1920.)—Fog, consisting of fine dust and associated with very low humidity, has been frequently observed by the author in various parts of Central Africa. At Borku meteorological observations were made thrice daily from May 1914 to April 1917, and a summary is given of the frequency of thick fog (visibility less than 0·5 km.) and medium fog (visibility less than 3 km.). The greatest frequencies are found in the months from the winter solstice on to the summer solstice, Feb. leading with thick and medium fog together forming 19 % of all observations. The months of greatest fog frequency are those when N.E. winds prevail. For thick and medium fog to form a wind speed of at least 8 to 10 m./sec. appears necessary. The height reached by the fog could not be measured, but exceeded 250 m. or 300 m. The danger to aerial navigation is pointed out. M. A. G.

1552. *Spectrophotometry of Skylight.* **D. Pacini.** (Soc. Spettros. Ital., Mem. 8. pp. 65–79, July–Aug., 1920.)—Describes a prolonged spectrophotometric study of the light from the sky under various conditions, as seen from Sestola (1090 m. above sea-level). The observations were made with a photometer employing an acetylene flame as standard. Curves are given for the relative intensities throughout the visible spectrum for the light from the zenith and various parts of the sky, at different times of day from dawn onwards, and under conditions of cloudlessness, misty and dull. The light was found to be selective, having a decided preponderance of blue. It also appears that a very pronounced reduction in the extreme violet is associated with the condensation of aqueous vapour. J. W. T. W.

1553. *Solar Variation and Weather.* **C. G. Abbot.** (Nature, 105. pp. 678–680, July 29, 1920.)—Since J. Herschel, Pouillet, and Forbes, nearly a century ago, devised instruments for measuring the solar radiation, the accuracy of these determinations has increased to such an extent that those made with the Ångström pyrheliometer can be relied upon within 2 %. The spectro-bolometer, invented by Langley forty years ago, has also become a reliable standard instrument, and a regular plan is now in use by which it will trace photographically an autographic solar-spectrum energy curve from 0·3 μ to 3·0 μ in ten minutes. On fine days such curves are obtained as the sun's altitude increases from 15° to 60°, together with simultaneous pyrheliometer observations. From forty points on each of the energy curves, forty straight lines are obtained, whose intersections with the zero line corresponding to no-atmosphere give as many separate determinations of the solar constant. The extinction at different altitudes, *i.e.*, different thicknesses of atmosphere, follows the Bouguer-Lambert Law. Since 1905 such observations have been taken at Mount Wilson, and have been credited with accuracy sufficient to point to the reality of the changes indicated in the solar-constant values. Sudden changes have taken place at times, such as a drop of about 10 % at the end of March 1903, and another about July 1912. But there are also changes corresponding to the phase of the sun-spot period, as well as short period irregular oscillations. The author considers that these latter, sometimes reaching 10 %, are larger than the sun-spot variation oscillation, which only reaches 4 %. He adduces evidence that the long-period changes are due to regular variations in the sun's surface temperature, while the others are due to changes of transparency in the outer layers, as evidenced by the varying contrast between the centre and the limb. Since 1918 observations have been made regularly at Calama, Chili, chosen on account of the almost complete absence of cloud, but only about three days out of four have been satisfactory. The variation shown there has been 7 %, though the probable error of a single observation is only 0·6 %. Correlation has been found by Clayton between the variations of solar radiation and those of temperature at Buenos Aires, with a definite lag between the time-curves; but the *régime* is different, as between winter and summer. This is attributed to the regular changes of position of atmospheric-action centres through the year. If this relation is maintained and confirmed, more solar observatories will be required so that no single day shall be missing, and then a complete forecast of changes of temperature and, it is also claimed, of precipitation will be available at least for certain regions. The author estimates the probable cost of the scheme. W. W. B.

1554. *The Path of a Ray of Light in the Gravitation Field of the Sun.* **G. B. Jeffery.** (Phil. Mag. 40. pp. 327–329, Sept., 1920.)—Anderson has given [see Abs. 1049 (1920)] a modification of the usual theory of the motion of a planet under Einstein's theory, from which he concludes that there should be no advance in perihelion. The particular integral of Einstein's contracted tensor equations for a particle of mass m at rest at the origin of polar coordinates gives for the line element in plane through the origin (1) . . $ds^2 = -\gamma^{-1}dr^2 - r^2d\theta^2 + y dt^2$, where $\gamma = 1 - 2m/r$. For the propagation of light we have $ds = 0$, which gives $\gamma^{-1}(dr/dt)^2 + r^2(d\theta dt)^2 = \gamma$, so that for a ray of light making an angle χ with the radius vector the velocity of propagation is v, where $v = \gamma(\cos^2\chi + \gamma\sin^2\chi)^{-\frac{1}{2}}$ . . (2). In order to avoid this dependence of the velocity of propagation upon the direction χ, it is usual to write $r = r_1 + m$, and to interpret r_1 as the actual measured radius vector. Then, neglecting the square of m/r, the velocity of propagation becomes $1 - 2m/r_1$, and is independent of the direction. The problem thus becomes identical with that of the determination of the path of a ray of light in a medium of variable refractive index $u = 1 + 2m/r_1$. This leads to the conclusion that a ray of light passing at a distance R from the sun would be deflected through an angle $4m/\mathrm{R}$. Einstein's equations of motion for a planet give $d^2u/d\theta^2 + u = m/h^2 + 3mu^2$ . . (3), where $u = 1/r$ and h is a constant. If we write $u_1 = 1/r_1$ so that neglecting squares of m, $u = u_1(1 - mu_1)$ and substitute in (3), it is readily seen that to the same degree of approximation the last term disappears, and we are left with the ordinary Newtonian equation giving no motion of the perihelion. This is Anderson's result. It would seem, however, that criticism might be directed against the introduction of the coordinate r_1 into the first problem rather than against its omission in the second. It is therefore of interest to inquire what the effect of a gravitational field would be upon the path of a ray of light if we regard r as the actual measured radius vector. The equation $d^2u/d\theta^2 + u = 3mu^2$. . (4) is derived, and compared with the differential equation of planetary orbits. The first term on the right-hand side of (3) represents the ordinary Newtonian attraction, and the second the small Einstein correction. Equation (4) might then be interpreted by saying that a ray of light is not subjected to the Newtonian attraction, but that the Einstein effect is the same as for a planet. The advance of the perihelion of a planet and the deflection of a ray of light thus appear, according to this view, as different manifestations of the same effect. Solving (4) by successive approximations, neglecting $(mu)^2$, and putting $u = 0$, it is shown that the ray is deflected through a total angle $4m/R$, which agrees with the usual theory. It appears that the deflection of a ray of light is the same whether we regard r or r_1 as the actual measured distances, but that the difference is important in the problem of the orbit of a planet.

A. E. G.

1555. *Comparison of Wave-lengths of Cyanogen Band in Sunlight and in a Terrestrial Source.* **A. Perot.** (Comptes Rendus, 171. pp. 229–232, July 26, 1920.)—This is an attempt to test Einstein's theory as to the difference indicated by actual measurements in the two cases. The author has found previously [Abs. 988 (1920)] that the terrestrial cyanogen band is not independent of pressure. Similarly on the sun he finds on isolating a region of about $\frac{1}{50}$th of the solar disc, that if this includes a mass of faculæ the wave-length is too great, and if it contains a filament of high-level Ca, the wave-length is too small, thus confirming Deslandres' views as to the vertical circulation. The author has reason to think that this high-level is not so very high, as he finds a very leisurely downward current at mean latitude 46°.

The terrestrial source used was the voltaic arc between carbon-poles at atmospheric pressure, the current being 10 amps. and the light viewed in a direction normal to the arc, and a constant has been applied to reduce to the required low pressure.

The regions studied were one central and the other four N., S., E., and W. respectively at a distance from the centre of the disc, equal to 0·722 radius. Details are given of the procedure and resulting measurements. The mean result is that the wave-length in the sun is 0·009 Å. greater, or 0·007 Å. if allowance is made for the velocity of descent. Thus Einstein's value is between the two.

W. W. B.

1556. *Interference Methods in Astronomy.* **A. A. Michelson.** (Comptes Rendus, 171. pp. 15–19, July 5, 1920.)—For the measurement of such very small quantities as the diameters of small asteroids and satellites, and the separation of very close binaries, beyond the resolving power of telescopes, the method of interference fringes has been in use more or less since 1896. This method consists of using only the parts of the objective at the ends of a diameter, a screen with slits covering the rest of the objective. The focal image consists of parallel bands, clearest when the light source is a point. The author proposes to use the method even to obtain stellar diameters, but it is readily applicable to such an object as a very close binary, since by rotating the screen the best definition found will indicate the direction perpendicular to the line joining the stars. Tests on Jupiter's satellites have been made at Lick Observatory, and the method has been also tried with the 40-in. Yerkes refractor and the 60-in. and 100-in. reflectors at Mount Wilson, and it was found that results of considerable value were obtained even when the "seeing" conditions were too poor for ordinary observations. Satisfactory measures of Capella as a binary were made, and orbit elements deduced. With modifications involving the use of prisms the method can be applied to the determination of small parallaxes and proper motions, and latitude variation. The degree of accuracy indicated is $\frac{1}{1000}$ second of arc, with a base of 100 in.; and preparations are being made at Mount Wilson to use a base of 20 ft., and if this is satisfactory, to extend to an even greater scale. W. W. B.

1557. *Telescopic Images.* **R. Jarry-Desloges.** (Comptes Rendus, 171. pp. 294–296, Aug. 2, 1920.)—The author has used telescopes of various apertures in several different places in France and Algeria during the last fifteen years, and now tabulates the quality of the seeing in various groups. (1) French stations, altitude less than 150 m. (2) French stations, altitude at least 900 m. (3) Algerian high-level stations. The scale of "seeing" is from 0 to 10 (0 being very bad), and the groups are classified according to steadiness of image, which in Algiers, at any rate, varies with the season, the cool months being better at some stations and worse at others. On the whole the chances appear to be better in Algiers, 250 nights a year at Sétif being suitable for planetary observations, and probably more still at Laghouat. W. W. B.

1558. *An Annual Term in Right Ascension.* **R. M. Stewart.** (Astron. J. 33. pp. 46–47, Aug. 24, 1920.)—Zimmer has recently [see Abs. 401 (1919)] drawn attention to differences in clock corrections between morning and evening observations, suggesting parallax as the only apparent explanation. The present paper objects that any parallax effect should vary in R.A. with the secant of the declination, which the observed effect does not. A similar objection is made to Tucker's suggestion of lateral refraction. Co-operation of different observatories is necessary to elucidate the problem and determine the law of dependence on the sun's hour-angle, on the latitude, and also possibly on the season of year (*i.e.*, the declination of the sun). W. W. B.

1559. *Origin of Heat of Sun and Stars.* **E. Belot.** (Comptes Rendus, 170. pp. 1563–1565, June 28, 1920.)—The difficulty of reconciling the age of the sun, as indicated by contraction, with the much greater periods demanded by geologists, appears to much the same extent in relation to the giant stars of low density, whose history, measured by contraction, must be much shorter still. The author suggests an alternative source of heat in collisions. Taking Eddington's figures, surface temperature 6000°, and internal mean temperature of the order of a million degrees, he finds that the heat generated by a collision is ample for the purpose, and obtains for the proto-sun's radius a value which fits his own law for the planetary distances. W. W. B.

1560. *Intensity Distribution in Solar and Stellar Spectra.* **B. Lindblad.** (Upsala Univ. Årsskrift, 1920. Mat. och. Naturvetenskap. 1. Nature, 106. p. 59, Sept. 9, 1920. Abstract.)—The author has studied the effective and minimum wave-lengths in grating spectra, and claims by this method

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to obtain an independent determination of absolute magnitude without using spectral lines, and thus supplying a check on Adams and Joy's results. Stars whose effective wave-length exceeds 426 $\mu\mu$ are giants. The effective temperature of the solar photosphere diminishes from 6200° at the centre to 5430° at the limb, this being attributed to the greater depth penetrated in the centre. 60 spectra of stars of known type and luminosity are given, with curves connecting minimum wave-length with absolute magnitude for the various spectral types. A special region in Cepheus is then examined in detail, including the dwarf Krüger 60 and two other stars found to be dwarfs. Red giants in this region suggest a distance of 4700 light-years for the galactic star cloud in this direction. W. W. B.

1561. *General Magnetic Field of the Sun.* **F. H. Seares.** (Observatory, No. 556. pp. 310–322, Sept., 1920.)—This gives a complete account of the work done at Mt. Wilson in following out the effect of Hale's discovery of magnetic fields in sun-spots. The proof of the existence of a general magnetic field in the sun rests less on the measurements made (of the order of one-thousandth of an Å. unit) than on the consistency of the inter-relations that appear. The dispersion used averages 4·9 mm. per Å. unit, the third-order spectrum being employed, with the 75-ft. spectrograph. The author describes the method, and the elementary theory on which it is based. He then details the exploratory observations, and the search for lines magnetically affected. The selected region was λ5800–λ6000, and very elaborate precautions were adopted to ensure unbiased measures, so that no measurer should know beforehand whether the photograph under the micrometer was direct or reversed, or to what region it belonged, the measures being all strictly differential. Miss Lasby only found 3 lines at all promising out of 30, and on these three a large amount of data was accumulated as the next step. The lines are λ5812·139 (Fe ,0), λ5828·097 (— ,0), and λ5929·898 (Fe ,2). The measures came out preponderantly positive in the northern and negative in the southern hemisphere, and they were revised by the quarter-wave plate, which confirmed their magnetic character. Next came the relation of field-strength to level, since it was clear that in spots the field fell off rapidly with increasing level. For this purpose 10 Fe lines, 8 Cr, 4 Ni, 5 V, and a single Ti line gave fairly accordant results; and these were translated into level by means of Mitchell's flash-spectrum measures. Again the results were accordant, except for V and Ti lines, a systematic difference between Fe and Cr now disappearing. Of 28 lines only 2 remained seriously discordant. The shell involved is very thin, the change from 50 γ to 10 γ only involving a thickness of 200 km. Thus the general field shows much more rapid change than that over sun-spots.

The next step was to locate the sun's magnetic axis, and figures are given showing an inclination of about 6° to the sun's rotation axis, and a period of 31·44 days. In a previous paper [Abs. 1284 (1919)] it had been found that the sun does not behave quite as a uniformly magnetised sphere, and the deviations were next attacked. The zones 10° to 45° N. and 10° to 45° S. latitude show considerable numerical accordance, but the intervening equatorial belt shows nearly double the field-strength, and a distribution constant only half as great. This result is as yet unexplained.

The author then marshals the internal evidence,

(1) Displacements are reversed by inverting the ¼-wave plate or rotating the ½-wave plate. This shows polarisation only associated with magnetic fields.

(2) Variation of displacement with latitude agrees closely with theory for uniformly magnetised sphere.

(3) Some lines displaced in sun-spots show no displacement in the general field. This is used as an argument against any systematic error that would vitiate the whole results.

(4) The three lines specially investigated over a long series of dates show shifts consistent with an inclination between magnetic and rotation axes of the sun.

(5) The intensity comes out the same whether large or small separation factor is involved.

(6) The assumption of a general field-strength decreasing with elevation removes a systematic difference between Fe and Cr, and is therefore more satisfactory than the alternative hypothesis that the whole is due to systematic error.

(7) An abnormal change of field-strength with latitude. This may be due to systematic error, but cannot modify any conclusion except the actual value of the magnetic field.

A final section considers the source of the field. Sun-spots tend to occur in pairs of opposite polarities. The preceding members of such are of opposite polarities in the two hemispheres, and the entire system apparently reverses with the beginning of a new spot-cycle. The magnetic axes are nearly normal to the surface, and the intensity of the field increases with the area of the spot. The general field does not conform to this, so the pores can hardly be called to account for it. Other serious objections are stated, and the matter is left quite open.

W. W. B.

1562. *Phenomena Observed on Mars during the Present Opposition.* **R. Jarry-Desloges.** (Comptes Rendus, 170. pp. 1486–1488, June 21, 1920.)—At Sétif important changes have been noted since the opposition of 1918. A large very dark patch in the region called Aeria, forming a sort of promontory connected with Syrtis Major, replaces the light grey "Astaboræ Fons," on the maps, but whereas the "Fons" was faint, small, and uncertain, the new patch is dark, large, and conspicuous. Moreover, Schiaparelli's "Nix Olimpica," measured in 1879, has reappeared, and has been re-measured as well as the whitish patch surrounding it, which extends principally to the south-east. After being unseen since 1879, the patch reappears, not in the Martian winter, as in 1879, but in the summer, when conditions of snow should be different. The author suggests an explanation by which cloud in summer replaces winter snow over a mountain range.

W. W. B.

1563. *Advance of Perihelion of a Planet.* **E. S. Pearson.** (Phil. Mag. 40. pp. 342–344, Sept., 1920.)—Anderson's transformation [Abs. 1049 (1920)] admittedly fails to account for any advance of Mercury's perihelion, and the present paper claims to explain the failure, which is due, says the author, to the neglect of the terms involving m^2, which is tantamount to ignoring Einstein's formula altogether. Carrying the expressions on to include these square terms, the author obtains the advance per revolution.

W. W. B.

1564. *Theory of Hyperion.* **J. Woltjer.** (Review by A. C. D. Crommelin. Nature, 105. p. 675, July 29, 1920.)—The author carries on Newcomb's investigation to a further stage considered impracticable by Newcomb. The period of Hyperion is commensurable with that of Titan, and the differential equations of motion of Hyperion are broken up into partial systems, giving inequalities proportional to successive powers of Titan's eccentricity. The author at present goes no further than the first power, but this gives a close approximation to the observed inequalities. The resulting ratio of Titan's mass to that of Saturn agrees fairly well with those found by Eichelberger and Santer, and the coefficient of the large inequality depending on Titan's eccentricity is near to that found by H. Struve from observation. Further stages of the work are to be hoped for. W. W. B.

1565. *Internal Constitution of the Stars.* **A. S. Eddington.** (Nature, 106. pp. 14–20, Sept. 2, 1920. Observatory, No. 557. pp. 341–358, Oct., 1920. Paper read before the British Assoc., Cardiff, Aug., 1920. Engineering, 110. pp. 352–353, Sept. 10, 1920. Abstract).—This presidential address to Section A is highly speculative. It deals generally with gaseous stars, and more particularly with "giants," on the assumption that they are sufficiently rarefied for their material to behave as a perfect gas. The author aims at probable values of the average molecular weight and the permeability to radiant energy, obtaining a likely value of 3·5 for the first from thermodynamical considerations. Giant stars of all types are said to have practically the same luminosity, and not to vary in mass more than 3 to 1. To reach the lowest type, M, a star should have at least 1/7 of the sun's mass. To reach the hottest type, B, a star should have at least twice the sun's mass. The greatest need is for measures of stellar diameters, and for this the interferometer method recently applied to Capella is promising, as it deals confidently with $\frac{1}{20}$ of a second of arc, which is about the apparent diameter of Betelgeuse. On the question of the source of the radiation energy, the author instanced Helmholtz's contraction hypothesis, and drew attention to the enormous discrepancies between the estimates of the earth's age by geologists and others, and those obtained by the contraction hypothesis. Cepheid variables suggest a much slower rate of dissipation. He thinks the contraction hypothesis must be shelved, and that a new source of energy will be found in "sub-atomic" energy. If all elements consist of H-atoms bound by electrons, then He for instance, 4 H-atoms and 2 electrons, having a mass slightly less than the 4 H-atoms, the loss of 1 part in 120 must represent some transformation. Rutherford says electric energy, and since his laboratory experiments have succeeded in making such transformations, it is quite likely that in the sun and stars the same is taking place on the large scale. The author considers that even if no more than 5 % of the original star mass consisted of H-atoms we should have ample heat liberated to satisfy all the anomalies. Very accurate measures of other atomic weights are required to show the deviation from integral values, so as to extend to them the work limited at present to the H-atom. W. W. B.

1566. *Differential Measurement of Proper Motions.* **E. A. Kreiken.** (Observatory, No. 554. pp. 255–260, July, 1920.)—The author makes a comparison between different methods in use at Groningen.

(1) Plates taken at different epochs measured alternately with Repsold machine; each coordinate of every star being measured to the nearest division line of the instrument, arranging for the same division line being used for the same star on each photograph.

(2) Stereocomparator.

(3) Both exposures on the same plate at suitable interval of time.

(4) One plate taken through the glass, and the pair put film to film together in the measuring machine.

In order to make the measures simultaneous and avoid the time taken over method (1), method (2) was tried, but the Groningen stereocomparator was not satisfactory. The other two methods require plates taken specially; so in order to make use of plates of any epoch not so taken, a fifth method was devised.

Two plates are put together in the Repsold measuring machine, in a suitable position with film side up. As both cannot be in focus together, focus on each in turn, having an index on the focusing screw to enable the change of focus to be made quickly. A discussion of results of the method leads the author to state that no systematic error is introduced, and the probable error is not appreciably increased. The plates used were of plate glass, so that the conclusions can only be taken as strictly applicable to plate glass. W. W. B.

1567. *Periodic Variations in Successive Layers of Stellar Atmospheres.* **H. Deslandres.** (Comptes Rendus, 171. pp. 451–456, Aug. 30, 1920.)—This is a continuation of previous work [see Abs. 1507 (1912)]. The spectrum of general sunlight is obtained by using a spectroscope without a lens. The great H and K dark lines show a bright reversed line in the middle. Using the K alone, three superposed rays, K_1, K_2, K_3, indicate three layers in the atmosphere, or including the surface also, four superposed layers in the solar spectrum, whose variations have been studied separately. The author cites his own work in this direction, leading to the conclusion that the sun is a bright-line star. Other bright-line stars have been classified and work commenced on Arcturus before the war. The light of the chromosphere has long been attributed to an electric origin and compared with atmospheric electricity on the earth. A radiation from the earth is claimed, similar to γ-rays but more penetrating, and another from the sun acting on the exterior layers of the atmosphere.

A further point arose in comparison between the sun and Nova Aurigæ, throwing doubt on the weak points of the collision theory. The author thinks it more probable that a nova is a single body and that its apparent outburst can be accounted for quite plausibly by the variations in the outer layers, according to a plan he describes. W. W. B.

1568. *Absorptive Power of Stellar Atmospheres.* **C. Nordmann.** (Comptes Rendus, 171. pp. 392–395, Aug. 17, 1920.)—This is the first result of an attempt to determine numerically the values, or minimum values of these absorptive powers. The author chooses for argument the ratio of the luminous radiation to the total radiation, and compares the effective temperatures of stars, when determined, with those of ideal "black bodies." The value of the "argument" diminishes in passing from stars of the solar type to cooler stars. In passing from class C to B it increases on the whole, contrary to expectation. Thus solar type stars compared with hotter ones emit proportionately less light and more heat. The sun itself, on account of its atmosphere, radiates more than its effective temperature would indicate. This atmospheric absorption admitted in the cases of the sun and earth is thus assumed for stars, and the statement is made that on the whole the general absorption of stellar atmospheres decreases regularly in passing from solar stars to those of hotter type. Particulars of a few stars are given. δ Persei, Algol, α Lyræ, α Persei, α Ursæ Majoris, γ Cygni, and Capella, and considerable deviations from the law are noted. The effective temperatures of these stars have been separately determined by the author and by Rosenberg, and the agreement is good, except for α Lyræ. W. W. B.

1569. *The Nebulæ.* (Lick Observat. Publ. vol. 13, 1918. Review in: Observatory, No. 554, pp. 265–266, July, 1920.)—This volume is very rich in pictures, especially remarkable being the series of 78 planetary nebulæ. No simple theory will explain all the different appearances. W. H. Wright's study of the spectra of planetary nebulæ and their nuclei shows the latter to be closely connected with the Wolf-Rayet stars. The order of evolution is still uncertain as between BPO and BOP, as the relative behaviour of different lines in the O-type and P-type spectra shows too many inconsistencies for either order to be definitely adopted. [The contents are dealt with *seriatim* in the next abstract.] W. W. B.

1570. *Researches on Nebulæ at the Lick Observatory.* (Nature, 105. pp. 489–492, June 17, 1920.)—This is a brief sketch by W. J. S. Lockyer of Vol. XIII of Publ. of Lick Observatory [see preceding Abs.] which contains six separate contributions.

Part 1 (pp. 9–42). **H. D. Curtis.** *Description of 762 nebulæ and clusters, photographed with the Crossley reflector,* June 1898. Of these 762, 513 are classed as spiral, 56 diffuse, 36 globular, 24 sparse, 78 planetary, 8 dark, and 47 unclassified. It is considered that from 700,000 to 1,000,000 small spirals are within the reach of large reflecting telescopes.

Part 2 (pp. 43–54). **H. D. Curtis.** *Occulting matter in spiral nebulæ.* This is found to be a relatively common feature, and reproductions of 77 of them are given to show it. "Coal sacks" and other possible occulting matter are mentioned, and also the constant radial velocity shown by the H and K lines in some spectroscopic binaries, which suggests the interposition of a non-luminous calcium cloud.

Part 3 (pp. 55–74). **H. D. Curtis.** *Planetary nebulæ.* All those nebulæ north of 34° S. decl., 78 in number, are reproduced either in photograph or drawing, and the brightness standardised by comparison of required exposure with that of a definite portion of the Orion nebula. He finds the smallest ones in or near the Milky Way, but the large ones on the whole fairly uniformly distributed in the sky, so that if connected with the galaxy they must be the nearest ones and ought to be included in parallax programmes.

Part 4 (pp. 75–184). **W. W. Campbell** and **J. H. Moore.** *Spectrographic velocities of bright-line nebulæ.* 138 are included, taken with the 36-in. Lick refractor or the 37-in. Mills reflector at Santiago, Chile, since 1913. Adopting a limiting diameter of 5″ for a "stellar" nebula, 31 "stellar" nebulæ give mean velocity 28 km. per sec., and 65 "non-stellar" nebulæ 31 km. per sec. Of 46 examined for evidence of rotation or internal motion, at least 19 indicated rotations about axes roughly perpendicular to the line of sight, while 25 gave evidence of internal effects. The variation in different parts of the Orion nebula ranges between + 9·7 km. and + 24·9 km., and does not point to rotation as a whole.

Part 5 (pp. 185–190). **R. E. Wilson.** *Radial velocity of greater Magellanic cloud.* From 17 planetary nebulæ the author derives a mean velocity of + 276 km., or + 261 km. correcting for solar motion. This is much greater than that for other planetary nebulæ (Part 4), pointing to exceptional conditions in the cloud, whose spiral appearance is also emphasised. The high velocity suggests those of spiral nebulæ, and the great Magellanic cloud is suggested as affording an opportunity for detailed study as an example of such spirals.

Part 6 (pp. 191–268). **W. H. Wright.** *Spectr aof gaseous nebulæ and wave-lengths of nebular lines.* (i) Measurement of wave-lengths and intensities of nebular lines. (ii) Study of nebular nuclei. (iii) Distribution of nebular radiations throughout the nebulæ. He says, " There are at present two general conceptions as to the nature of stellar evolution, one of which assumes a falling temperature throughout the period of a star's development, while the other predicates a rise to maximum and a subsequent decline ; both of these views assume a nebula as the primordial state. As between these two hypotheses, the present observations undoubtedly favour the first, since they add to the proof that the gaseous nebulæ are associated only with the hot stars." Comparison of photographs with spectrographs taken without a slit gives valuable information as to the distribution of different gases in the nebulæ. W. W. B.

1571. *Spectrum of Nova Cygni.* **Burson.** (Comptes Rendus, 171. pp. 469–471, Aug. 30, 1920.)—With the 2-prism spectrograph at Meudon, Burson examined the spectrum with a dispersion giving 88 mm. between λ495 and λ387. It was of the usual type, with large double lines of H and Ca, the dark displaced strongly towards the violet, and the bright relatively displaced towards the red. A comparison spectrum of Fe and Ti was used. Figures are given for Aug. 25 and Aug. 27 of the H and K lines of Ca and H_β, H_γ, and H_δ of hydrogen. On the latter day a tentative identification of two lines is suggested with parhelium. Two absorption rays of Ca are also shown in the wide H and K lines, showing a different radial velocity. **d'Azambuja.** (Comptes Rendus, 171. pp. 466–469, Aug. 30, 1920.)—Two prismatic cameras were employed at Meudon Observatory and details are given, the comparison spectrum being obtained from α Cygni. The portion identified lies between λλ4861 and 3060. Numerous lines, showing on a fairly bright continuous spectrum, include the H series from H_β to H_θ, beyond which as far as H_ξ the nova and the comparison spectrum do not agree. Beyond λ3650 is shown only a continuous spectrum with a few faint and diffuse condensations. A table of wave-lengths is given with deduced radial velocities. No marked difference is found from other novæ. **A. Fowler, W. J. S. Lockyer, W. F. Denning.** (Nature, 106. pp. 32–33, Sept. 2, 1920.)—Fowler considers the star has followed the normal course, except that the rise may have been more prolonged and the decline more rapid. On Aug. 22 bright lines were not discernible with a small spectroscope on 3-in. refractor, so maximum had not been reached then. On Aug. 26, with 10-in. reflector of Penylan Observatory, Cardiff, magnitude was about 2·8, and bright lines well developed. H_α was conspicuous and the four lines in the green assumed to be H_β, 4924, 5018, and 5169. No marked change by Aug. 28.

W. J. S. Lockyer, at Sidmouth, obtained about 4 spectra each night from Aug. 22 to 29, except 23rd and 27th, when it was cloudy, as it had been also on Aug. 21 when the discovery was first published. Spectra on Aug. 22 were of α-Cygni type. By Aug. 24 star had brightened, lines became more diffuse and broader, and an increasing number were shown towards the violet. On Aug. 25 magnitude about the same, lines more diffuse and bright ones more conspicuous. Aug. 26 reduced to 2·8 mag. Increase in intensity and width of bright lines made the dark H lines appear less broad. Aug. 28, no great change except that bright H lines show signs of doubling. This splitting up was still more pronounced on Aug. 29. On all nights large radial velocity was indicated.

W. F. Denning states that the nova brightened until night of Aug. 23, when it was of second magnitude. By Aug. 29 it had declined to 3·9 and probably will not be visible to the naked eye much longer. W. W. B.

1572. *Nova Cygni.* **C. Nordmann.** (Comptes Rendus, 171. pp. 492–494, Sept. 6, 1920.)—After unfavourable weather at maximum, observations were obtained with the photometer at the Paris Observatory on Aug. 26, 27, and 29. On Aug. 26, during a short interval between clouds, the nova was compared with Polaris, and its inferred magnitude was 2·29, but clouds weaken the value of the result. On Aug. 28 and 29 the comparison star was γ Cygni, and the resulting magnitudes were respectively 3·43 and 4·01 with probable error ± 0·05. Adopting his own determination, 5620°, for the effective temperature of γ Cygni, Nordmann infers an effective temperature for the nova of about 6100° on Aug. 27, and 7800° on Aug. 29. He considers these relatively low figures (far below those of hydrogen and helium stars) to contradict any theory of collision for the nova. He is uncertain how to explain the increase in temperature between Aug. 27 and 29.

(Engineering, 110. p. 353, Sept. 10, 1920. Paper read before the British Assoc., Cardiff, Aug., 1920.)—W. F. Denning discovered this star on Aug. 20. At Greenwich on Aug. 21 it was noted as of 3·5 magnitude, a pale yellow star with continuous spectrum and some bright lines. On Aug. 22 at Sidmouth, Lockyer noted an increase to 3rd magnitude, and a spectrum resembling α Cygni. On Aug. 26 Dyson and Fowler, at Cardiff, noted that the magnitude which had reached a maximum of 2 on Aug. 25 had now sunk to 2·8. Lockyer's spectrum showed hydrogen and Ca, Mg and Fe lines. The special feature of this nova is the slow rise to maximum.

(Harvard Bull. 729. Astron. Nachr. 5060. Nature, 106. p. 91, Sept. 16, 1920. Abstract.)—R.A 19h. 56m. 24·77s. N. Decl. 53° 24′ 1·3″ (epoch 1920·0) annual precession + 1·50s. + 9·7″. Plates taken 15 years ago by M. Wolf show that the star must then have been fainter than 17 mag. Plates taken 12 years ago by Franklin Adams show that it must then have been fainter than 15 mag. Plates taken at Harvard 1920 Aug. 9 with 1-in. lens also fail to show it, so it must then have been fainter than 9·5 mag. On Aug. 16, Nils Tamm, in Sweden, took a photograph showing it of 7th mag., and a Harvard plate of Aug. 19 shows it 4·8 mag. Maximum occurred on Aug. 24, so the rise took more than a week, the total increase in light being at least 15 magnitudes, as against 11 magnitudes for Nova Aquilæ of 1918.

Spectrum of Nova Cygni III. **A. L. Cortie.** (Nature, 106. p. 79, Sept. 16, 1920.)—On Aug. 29 and 30 and Sept. 6 spectrograms were obtained at Stonyhurst with the prismatic camera. At first the prominent features were bright H bands, of a width of about 20 Å. units and all double, also enhanced Fe lines 5316, 5169, 5019, and 4924, of which only the last named showed on an isochromatic plate taken Sept. 6. Broad bands were shown between H_β and H_γ and prominent lines between H_γ and H_δ. Some of these were identified with Fe. The K (Ca) band was double and extended over 15 Å. units. Sept. 6, visual magnitude was below 5 and no obvious change was shown by Sept. 10, when a faint photograph showed a very bright H_α. Fe 4924 was also still shown. W. W. B.

1573. *Photometric Measures of Nuclei of some Typical Spiral Nebulæ.* **J. H. Reynolds.** (Roy. Astron. Soc., M.N. 80. pp. 746-753, June, 1920.)—The author suggests seven different classes of spiral nebulæ: (1) Consisting entirely of amorphous nebulosity, (2) showing incipient condensation in outer whorls only, (3) condensation considerably advanced towards nucleus, (4) all condensed except nucleus itself, hazy background, (5) condensation more definite and background practically free from haze, (6) condensation only of intermediate portions between nucleus and outer whorls, (7) no definite nucleus at all. The present paper deals with five nebulæ of classes (1), (4), (5), (6), and (7) respectively, curves of light being shown for a section of each through the nucleus. The last one, N.G.C. 4826, though classified as (6), may almost be included under Class (1). The curves vary according to the plates used and their sensitiveness to different parts of the spectrum.

The author discusses the bearing of his data on the nature of the nebulæ. The outer regions are bluer than the nucleus, a fact which is undoubted, but difficult to explain. The spirals may be incipient galaxies, but too little is known about the nature of novæ in spirals as compared with galactic novæ. The amorphous condensation is probably not a conglomeration of star discs. A few other generalisations are suggested, but the author's conclusion is that the real nature of the spiral nebulæ is as yet unknown. W. W. B.

1574. *Real Motions of the Stars.* II. **B. Boss.** (Astron. J. 33. pp. 17–24, June 12, 1920.)—This extends the investigation [Abs. 1074 (1918)] which included only parallaxes by Adams and Joy, to all available material, and is greatly concerned with systematic corrections to different sets of parallax determinations in order to harmonise the various results. The spectroscopic parallaxes (Mt. Wilson) for the great majority of stars yield more accurate data than any others, but this probable error is a minimum for zero parallax and increases according to formula p.e. $= \pm (0{\cdot}0031'' + 0{\cdot}0833''\pi)$, so that for 10th visual magnitude stars (mean parallax $0{\cdot}0034''$), the probable error is of the same order as the parallax; and so the spectroscopic results for stars fainter than this cannot be expected to furnish reliable data. The probable error of a parallax determined in this way seems to be independent of the number of plates used, so that multiplication of plates is unnecessary. The mean residuals grouped from M giant to M dwarf show a systematic tendency, but the probable error is large enough to make this of doubtful reality.

The determinations made by other methods have been treated specially to make them more accordant, but they point to the possible existence of terms depending on the right ascension α, and even on 2α, which the spectroscopic determinations do not countenance. W. W. B.

1575. *Change of Period in Variable Bailey No. 33 in Cluster M5.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 80. pp. 640-642, May, 1920.)—The author discusses Barnard's observations of this star, and concludes that the period changed abruptly between 1903 and 1904, between 1913 and 1915, and between 1918 and 1919. The change is very small, but seems well established. He obtains for

1899 to 1903	12h. 2m. 7·293s.
1904 to 1913	12h. 2m. 7·353s.
1915 to 1918	12h. 2m. 7·077s.

and puts forward a suggestion which brings this star into line with other variables in which he has found periodic changes. He points out that Barnard's observations are probably correct to within ¼ minute, or far more accurate than those of long-period variables as ordinarily observed, which are often in doubt to a couple of days, whereas in proportion to Barnard's observations they should be certain within 2¼ hours. W. W. B.

1576. *Temperature of Formation of a Star in a Homogeneous Indefinite Nebula.* **A. Véronnet.** (Comptes Rendus, 170. pp. 1565-1567, June 28, 1920.)—Proceeding with his analysis [see Abs. 527 (1920)], the author concludes that a solid central nucleus is possible in the sun, as well as in the earth. He finds the fourth power of the temperature of formation to be proportional to the mass and density of the body and also to the square root of the density of the nebula in which it is condensed. Also for bodies formed from the same elements, in the same medium and in the same period, the temperature of formation would be proportional to the fifth root of the mass or to the square root of the radius, excluding the case of collisions. He finds the temperature of formation of the sun to be at least equal to its present temperature and the max. value of the period of formation to be 200 million years, with an accuracy within 10 %. W. W. B.

LIGHT.

1577. *An Instrument for the Measurement of the Visibility of Objects.* **L. A. Jones.** (Phil. Mag. 39. pp. 96–134, Jan., 1920. Comm. No. 79 from the Eastman Kodak Co.'s Research Lab.)—The research originated in the need for an instrument for comparing the values of various methods of diminishing the visibility of ships, as a precaution against submarine attack. The earlier part of the paper deals with theoretical considerations and nomenclature. Subsequently the part played by the brightness of an object in relation to that of its background is analysed and a curve is presented relating sensibility of the eye to brightness-contrast and field brightness. In the initial discussion it is assumed that brightness of an object is independent of distance, but the veiling effect of intervening luminous haze, etc., is next considered. This leads to a description of the apparatus for the measurement and specification of visibility, in terms of the veiling glare and the brightness of the background against which the object is viewed. The action of the instrument is analogous to the production of a veiling screen consisting of material particles distributed in the foreground space. Calibration curves are appended. The apparatus has also been applied to determine increase or diminution in visibility occasioned by the use of colour-filters. J. S. D.

1578. *Liquid Plane-Parallel Plate Interferometer.* **H. P. Waran.** (Engineering, 110. p. 383, Sept. 17, 1920. Paper read before the British Assoc., Cardiff, Aug., 1920.)—Instead of a Lummer plane-parallel plate of glass a liquid film of water or oil floating on mercury was used. A vertical beam of light fell on a silvered mirror mounted obliquely in the water; in later arrangements a prism in one end of the trough was substituted for the mirror. When the trough was steady two parallel bands of fringes were obtained, the one displaced with respect to the other, due apparently to the circumstance that the reflections from the upper surface (air–water) and the lower (water–mercury) did not take place under the same conditions. Hence a Lummer glass slab was placed on the mercury, and two distinct systems of fringes were observed, displaced as indicated. With polarised incident light, the one or the other system vanished, according to the plane of polarisation, because each system belonged to one of the components of the elliptically polarised light resulting from the metallic reflection. A study was made of the phase differences between these two components, and it was shown that these phase differences, and the optical constants of the liquid and solid (mercury or silver on glass) film can be determined experimentally. Castor oil was found preferable to water as liquid; glycerin did not answer owing to its hygroscopic character. A. W.

1579. *Scattering of Light by Gases.* I. **Rayleigh.** (Roy. Soc., Proc. 97. pp. 435–450, Aug. 3, 1920.)—In earlier papers [Abs. 517 and 664 (1918)] it was shown that the light scattered by gases free from dust was not perfectly polarised, but that a residual defect of polarisation remained, which was characteristic for each gas. The present paper gives a description of a repetition of part of the earlier work, using a modified and improved apparatus. A full description is given of the apparatus used and of the methods of measurement. The most noteworthy feature is the means adopted for securing a black background. A straight tube, blackened on the inside, was used in the earlier work, but as no blackening material proved satisfactory a curved horn of green glass was used in place of the straight tube. This horn was covered outside with black paint and wrapped in black cloth as an additional precaution. Any light reflected into the mouth of this horn was reflected internally from side to side and was soon lost completely, so that a black background was obtained which gave no luminosity sufficient to produce the slightest photographic impression in an exposure of 24 hours or more with the most sensitive plates. The results obtained for various common gases are shown in the following table:—

Gas.	Intensity of Weak Component Polarisation (Strong Component = 100).
Hydrogen	3·83
Nitrogen	4·06
Air	5·0
Oxygen	9·4
Carbon dioxide	11·7
Nitrous oxide	15·4

The results, except in one particular, thus confirm those previously obtained. A. W.

1580. *Light Scattering by Air and the Blue Colour of the Sky.* **R. W. Wood.** (Phil. Mag. 39. pp. 423–433, April, 1920.)—(1) The intensity of the light scattered by a given thickness of dust-free air in a tube illuminated by concentrated sunlight, has been compared photometrically with the light of the sky, by reducing the intensity of the latter until a match was secured. The ratio of the two intensities was compared with the calculated ratio, making certain assumptions in the case of the light of the sky, and a fair agreement found.

(2) The intensity of the light scattered by dust-free air nearly in the direction of the incident light has been examined and found to be not very different from the intensity scattered in a perpendicular direction. It is theoretically twice as bright, but the conditions of the experiment did not permit of the determination of a difference of this amount. This indicates that the enormous increase in the intensity of the sky close to the sun's limb (over 20-fold) results from diffraction by motes in the air, and would be wholly absent if the atmosphere were perfectly clean.

(3) The scattering power of the air near the ground on the clearest days in the country has been found to be about 2·6 times the average scattering power of the atmosphere. AUTHOR.

1581. *Scattering of Light by Dust-free Liquids.* **W. H. Martin.** (Journ. Phys. Chem. 24. pp. 478–492, June, 1920.)—The methods employed to obtain dust-free liquids consisted of: (1) Distillation, water, for example, being evaporated from one bulb of an exhausted glass apparatus composed of two bulbs joined by a tube and condensed in the other bulb. The first distillates are shaken back into the first bulb so as to wash back the dust; the condenser bulb containing the condensate is finally sealed off. Other distillation methods were also used. (2) Precipitation of gelatinous aluminium, cadmium, or zinc hydroxide in corked flasks and allowing to settle. (3) Cataphoresis of water.

Liquids thus treated were found still to scatter light, that of short wave-length to a far greater extent than that of long wave-length. Some agreement is shown by the liquids examined with Rayleigh's relationship, $(\mu - 1)^2/n$, where μ is the refractive index of the medium and n the number of scattering particles per unit of volume [see Strutt, Abs. 41 (1919)].

Aliphatic compounds scatter relatively little light, benzene and its derivatives decidedly more and chloronaphthalene still more; with certain exceptions the intensity of the scattered light increases with increasing molecular weight in one and the same class of compounds. For those liquids which scatter very little light, this light is fairly completely plane polarised, the polarisation decreasing in extent as the light-scattering power increases. The scattered light is far less completely polarised by the liquid than by the corresponding gas, but, where the required data are at hand—for benzene, ether, and carbon disulphide—the order of the compounds as regards this polarisation is the same for both phases. The polarisation is very much less complete with any of the liquids studied than with a colloidal silica solution.

Evidence is adduced showing that the phenomena observed are due to scattering and not to fluorescence. T. H. P.

1582. *Effect of Molecular Impacts on Interferences with Large Path Difference.* **G. Gouy.** (J. de Physique et le Radium, 1. pp. 3–11, Jan.–July, 1920.)—A spectral ray is not a homogeneous ray, that is to say an indefinite succession of equal vibrations. It differs from this ideal in many respects, and to take account of this fact the following hypothesis is put forward: the molecules actually produce regular vibrations, but the final result is modified (1) by the Doppler effect due to the velocity of the molecules, and (2) by the collisions which the molecules experience, these collisions producing abrupt and fortuitous changes of phase and amplitude. An examination of this theory is attempted by considering interferences with large path differences, and using Michelson's results for the visibility of fringes. The results of the discussion show that if the above hypothesis is to account for the facts, it would be necessary for the probability of an impact to be greater than that shown by the kinetic theory in a ratio which varies from about 35 to 50 for Li, Na, Cd, and Zn, and for Cu, Mg, Ag, and Au, from 100 to 200, so far as can be judged. Similar conclusions are reached whether the spectral lines considered are spark lines or derived from the Bunsen flame [see Abs. 1130 (1917)]. A. W.

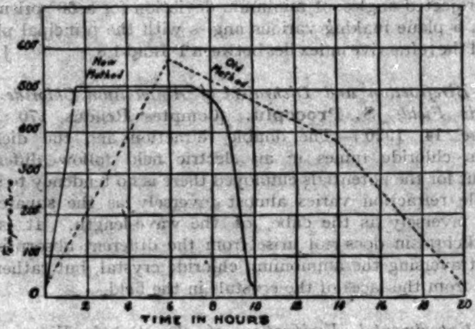
1583. *Superposing of Cross-line Photographic Screens at Small Angles.* **S. Lees.** (Manchester Lit. and Phil. Soc., Mem. 63. No. 4 [pp. 1–26], 1918–1919. Published Aug. 16, 1920.)—Discusses the general characteristics of the patterns obtained by superposing two half-tone plates of like type, at small angles. The cases of intaglio, ordinary half-tone, and "chessboard" screens are discussed in detail. In these cases it is shown that the coarse square framework which is seen is similar in type to that of each of the constituent screens. Formulæ for the pitches of these frameworks are deduced, and it is shown that if the pitches of the constituent screens are in the ratio of simple whole numbers, a coarse square framework appears, whose pitch varies as cosec $(\theta/2)$, and thus becomes infinite when θ tends to zero. In other cases it is shown that the pitch remains finite always. It is also shown that the resultant pattern of two intaglio screens is not the negative of the pattern produced by the negatives of the two original constituent screens. The cases which arise when θ is large are not dealt with. J. W. T. W.

1584. *Refraction of Oblique Rays in a Prism.* **H. Erfle.** (Zeits. Instrumentenk. 40. pp. 82–87, May; 105–111, June, and pp. 129–136, July, 1920.)—Forms a continuation of previous work on this subject [see Abs. 44 (1919)] in which the equations previously determined are obtained by a simpler process of analysis. A table is given for the true and the projected angles of minimum deviation for a 60° prism when the ray lies in a plane making various angles with the principal plane of the prism, and the refractive index lies between 1·3 and 1·8. J. W. T. W.

1585. *Birefraction and Dichroism of Ammonium Chloride Fumes in the Electric Field.* **S. Procopiu.** (Comptes Rendus, 170. pp. 1445–1447, June 14, 1920.)—The double refraction and the dichroism of ammonium chloride fumes in an electric field follow different time-courses, but for the potentials employed there is no tendency to saturation. The double refraction varies almost inversely as the square, and the dichroism inversely as the cube, of the wave-length. It is probable that the dichroism does not arise from the different absorptions of the two rays traversing the ammonium chloride crystal, but rather from the reflections from the faces of the crystals in the field. T. H. P.

1586. *Experimental Verification of the Doppler-Fizeau Principle.* **H. Buisson** and **C. Fabry.** (J. de Physique, 9. pp. 234–239, July, 1920.)—A disc of white paper, 16 cm. diam., was rapidly rotated about its vertical axis at a speed of about 200 turns per second. Points near the edge of the disc thus had a velocity of about 100 m. per second. A Cooper Hewitt mercury lamp, in the form of a long tube, was placed horizontally over a diameter of the disc. Considering points near the ends of this diameter, each receives light perpendicular to its direction of motion, and will emit light identical with that of the lamp. They thus serve as luminous points with equal and opposite velocities of about 100 m. per sec., and an observer at a certain distance away in a direction perpendicular to the diameter, looking at the disc at a very oblique angle, will see it as an elongated ellipse. The Doppler-Fizeau effect should produce a small difference in wave-length between the light from one end of the major axis of the ellipse and that from the other. This effect was verified, using an étalon, with silvered plates, of 65 mm. thickness. The order of interference, with a path difference of 130 mm. is about 240,000, and in passing from one edge to the other the change observed is about one-sixth of a ring, which is quite easy to detect visually. Photographs taken in succession of the two ends of the diameter, with only 5 seconds exposure, gave good numerical results. The difference in velocity was 201 m. per sec. and the order of interference for the violet radiation used was, with the path difference of 130 mm., 298,300. The variation to be observed should therefore be 0·200. Direct measurement gave a value 0·206, which is remarkably close to the theoretical value, considering that no special precautions were taken to perfect the details of the method. **A. W.**

1587. *Annealing Optical Glass.* **L. H. Adams and E. D. Williamson.** (Optical Soc. of America, J. 4. pp. 213–223, July, 1920.)—After a general discussion of the mechanism of annealing, and its effect on the straining of glass, the author describes a new method which has been extensively used in America for the annealing of optical glasses. He first defines an annealed glass as one in which the optical path difference as measured along the middle of a slab is not greater than $5\mu\mu$ per cm. The "annealing temperature" is defined as the temperature at which the strain is reduced from 50 to $5\ \mu\mu$ in a specified time, and the "annealing range" is arbitrarily defined, for convenience, as that 150-deg. interval lying immediately below the "annealing temperature" for one minute. Temperature changes below the annealing ranges do not readily affect the permanent strain. Experiments made on the rate of release of strain at various temperatures showed that this process, at constant temperature, proceeds according to the empirical relation $1/D_n - 1/(D_n)_0 = At$, where $(D_n)_0$ and D_n are the birefringences originally and at the end of time t, respectively, while A is a constant termed the "annealing constant" for a particular glass at a particular temperature θ. The relation between A and θ is found to be expressed by the empirical relationship $\log A = M_1\theta - M_2$, where M_1 and M_2 are constants of the particular kind of glass.



Instead of the usual practice, in which the glass is heated to a temperature at which the strain disappears almost instantaneously, and is then slowly cooled to ordinary temperature, the method proposed in the present paper is to heat the glass rapidly to the annealing temperature (which is below the highest temperature used in the old method), maintain it constantly at this temperature for about 3½ to 12 hours, and then cool it rapidly (in about 2 to 4 hours) to room temperature. The rate of cooling increases as the cooling proceeds, being initially 24 deg. C. per hour for a plate 2 cm. thick, and 6 deg. C. per hour for a plate 4 cm. thick. Except at the start the rate of cooling is doubled at every 20 deg. fall in temperature. The temperature curve used in both methods is shown in the Fig. while the annealing temperatures for different kinds of glass are given in the following table:

Kind of Glass.	Annealing Temperature for 2-cm. Plate.	Annealing Temperature for 4-cm. Plate.
Borosilicate crown	542 °	522 °
Ordinary crown	515	494
Light barium crown	553	534
Heavy barium crown	593	578
Barium flint	495	474
Light flint	409	391
Medium flint	419	403
Heavy flint	408	392
Extra heavy flint	382	364

J. W. T. W.

1588. *Effect of Strain on the Properties of Optical Glasses.* **G. Berndt.** (Zeits. Instrumentenk. 40. pp. 20–27, Jan ; 37–42, Feb. ; 56–61, March, and pp. 70–75, April, 1920.)—Describes experiments on the effect of annealing or sudden cooling upon various kinds of optical glass as regards compressive strength, strength in tension, or bending, and modulus of elasticity. It was found that excessive strain produced a change of some 0·8 % in density and 2·2 % in refractive index. Hooke's law was found to hold with great accuracy for glass almost up to the breaking-point. J. W. T. W.

1589. *Effect of Motion of Source on Velocity of Light it Emits.* **C. Poli.** (Accad. Sci. Torino, Atti, 55. 7. pp. 227–232, 1919–1920.)—Proposes a theory of the effect produced on the velocity of light emitted by a source in motion and concludes that: (1) if the velocity of the source be u, the velocity of the light emitted is $c + u \cos \alpha$, if α is the angle between the direction of motion of the source and the direction of propagation of the light, whatever the previous reflections or refractions; and (2) the velocity of the monochromatic light emitted by the source, in a medium of refractive index n moving with velocity v, is $c/n + u \cos \alpha + (1 - 1/n^2)(v \cos \beta - u \cos \alpha)$, where β is the angle between the direction of propagation of the light and the direction of motion of the medium. J. W. T. W.

1590. *Deviation of Light in a Uniform Electromagnetic Field* (*Einstein Theory*). **R. Serini.** (Accad. Lincei. Atti., 28. ii pp. 178–183, 1919.)—A uniform electromagnetic field is non-euclidean. The resultant deviation of a ray of light is calculated. It is too small for verification by any experimental means at our disposal. A. D.

1591. *The Michelson-Morley Experiment.* **A. Righi.** (Comptes Rendus, 170. pp. 1550–1554, June 28, 1920.)—The author here gives his calculations of the amounts of fringe displacements which should occur according to his former argument [Abs. 1169 (1920)]. G. W. de T.

1592. *Threshold Phenomena in Radiation.* **J. Kunz.** (Phys. Rev. 15. pp. 129–130, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—Thresholds seem to appear generally when light energy is transformed into kinetic energy of electrons or *vice versa.* It may be assumed that thermal energy of agitation and intrinsic electromagnetic energy is stored up in the atoms or molecules; also that for every degree of freedom there is a threshold in this energy, and that the entropy corresponding to the intrinsic energy is a universal constant. The author deduces an expression for the calculation of the entropy of the oscillators which leads directly to Planck's law of radiation. E. E. F.

1593. *Theory of Colour Vision.* **R. A. Houstoun.** (Phil. Mag. 38. pp. 402–417, Sept., 1919.)—A further development of the theory already put forward by the author [Abs. 1032 (1916)], numerical examples being given for the purpose of showing that equally correct results are obtainable as on the Young-Helmholtz theory. L. H. W.

1594. *Photoelectric Photometers.* **A. H. Compton.** (Am. Illum. Eng. Soc., Trans. 15. pp. 28–33, Feb. 10, 1920.)—When light strikes an alkali metal, electrons are thrown off. If a p.d. is applied between an alkali metal and another electrode, a current which is proportional to the intensity of the incident light ensues. Such a cell may be applied for photometric measurements, but is subject to two serious difficulties: (*a*) The very low current, of the order of 10^{-11} amp., necessitating the use of electrostatic methods, and (*b*) the fact that the cell is most sensitive to blue, and almost unaffected by red and yellow light. The author has attempted to magnify the current by using a three-electrode valve and to overcome the colour-difficulty by inserting suitable tinted screens in the path of the light. For practical work potassium is the most convenient metal to use; calcium and rubidium approach most nearly the sensibility curve of the eye to light of various colours, but melt too readily. Various precautions necessary in the use of such cells are described, and it is claimed that under favourable conditions the probable error of measurement can be reduced below 1/10 of 1 %. Other devices such as the selenium cell and the thermopile do not appear adaptable to industrial photometry. J. S. D.

1595. *Sensitiveness of the Eye to Light and Colour.* **P. G. Nutting.** (Optical Soc. of America, J. 4. pp. 55–79, March, 1920.)—The paper presents the conclusions of the Standards Committee on Visual Sensitometry, and summarises available knowledge on (1) Visibility of radiation, (2) Intensity and contrast sensibility, (3) Chromatic sensibility, (4) Rates of adaptation, and (5) Absolute sensibility. A table is presented specifying the amount of radiant energy necessary to produce a fixed sensation of brightness throughout the spectrum, based on a mechanical equivalent of 0.0015 watt per lumen for max. luminosity at $556\ \mu\mu$. Curves show the distribution of visibility in the spectrum for the normal dark-adapted eye ("cone-vision" and "rod-vision"). Tables are next presented illustrating colour-sensibility in terms of dominant hue, saturation, and intensity. Sensibility to intensity, as indicated by (1) least perceptible threshold, (2) least perceptible contrast in brightness, and (3) an intensity just uncomfortably glaring, is next dealt with, and curves are given showing the relation of these three conditions to brightness of field. Rates of increase and decrease of sensibility when an eye is suddenly exposed to a given brightness, or the brightness subsequently withdrawn, are also given. The influence of diameter of pupil on perceptible brightness (in lumens per mm.^{2} at the retina per milli-lambert of field brightness) is next discussed. Finally the report presents some data on the minimum energy necessary to excite the sensation of light, in relation to angle subtended by the luminous object. The minimum value recorded is $17 \cdot 1 \times 10^{-10}$ erg per sec. J. S. D.

1596. *Origin of the "Cyanogen" Bands.* **S. Barratt.** (Roy. Soc., Proc. 98. pp. 40–49, Sept. 1, 1920.)—Observations have been made of the spectra of the flames of a number of gases containing carbon, hydrogen, nitrogen, and oxygen. The cyanogen bands are strongly developed in the coal-gas–nitrous oxide flame and are also given by the flames (i) coal-gas–air (+ ammonia, nitroethane or piperidene), (ii) CO–air and NH_3, (iii) $(CN)_2$ and HCN–air, (iv) methylamine–air, and other nitrogenous organic substances. The bands are absent from the hydrogen–nitrous oxide flame if all traces of carbon are excluded, and are not found in (i) hydrocarbon–oxygen flames in general, (ii) ammonia–oxygen. The results show that the presence of carbon is essential to the production of the cyanogen bands. The appearance of the cyanogen bands is, under appropriate conditions, a more delicate test for carbon than that of any of the other bands associated with that element. On the other hand, this spectrum is not necessarily developed when both carbon and nitrogen are present. It is not found, for example, in the flame CO–oxides of nitrogen. The conclusion of Grotrian and Runge [Abs. 1528 (1914)], that the cyanogen spectrum is to be attributed to nitrogen, is shown to rest on assumptions which are not confirmed by the results now obtained. The cyanogen spectrum provides a very delicate test for the presence of compounds of nitrogen admitted in the form of a gas to hydrocarbon flames burning in air, since elementary nitrogen does not appear, under ordinary circumstances, to be effective in producing cyanogen bands in such flames. The intensity of the cyanogen bands, when carbon compounds are admitted to the hydrogen–nitrous oxide flame, was not found to bear any simple relation to the amount of carbon added. A. W.

1597. *Balmer Series of Hydrogen.* **L. Silberstein.** (Roy. Soc., Proc. 98. pp. 1–12, Sept. 1, 1920.)—The object of this paper is to apply the quantum theory of spectrum emission by atomic systems containing an *aspherical* nucleus, given in a previous paper [Abs. 375 (1920)], to the Balmer series of hydrogen. Calculations based on the most recent measurements made by Cortis of the first six members of the Balmer series show that the hydrogen nucleus is oblate, the asphericity σ being given by $\sigma = (2Nch/e^2)^2 \,.\, (A-B) = +\,9 \cdot 007 \times 10^{-5}$, where N is the Bohr value of the Rydberg constant, c the velocity of light, and e the charge on the nucleus. From this result approximate calculation gives for (A—B), the difference of the principal moments of inertia of the hydrogen nucleus, the value $+\,2 \cdot 51 \times 10^{-21}$ cm.^{2} If we suppose the nucleus to be a homogeneous rotational ellipsoid of axes $2a$, $2b$, the former being the axis of symmetry, further calculation gives the result $b \geqq 1{\cdot}12 \times 10^{-10}$ cm. Formulæ are derived for the fine structure of H_α and H_β. For H_α fifteen components are calculated, which are arranged in three groups of four each (the lines in each group being extremely close together) and three single lines. Further experimental work will be necessary to decide whether this scheme agrees with actual facts. Similarly, six components are found for H_β. A. W.

1598. *Origin of Spectra.* (Engineering, 110. pp. 382–383, Sept. 17, 1920. Discussion before the British Assoc., Cardiff, Aug., 1920.)—**A. Fowler** gave an account of some of the observations which theory had to explain. Different series of lines can be sorted out of the multitude of lines by their different electrical, magnetic, and other properties, and formulæ have been found for the various series by Balmer, Paschen, Ritz, Rydberg, Hicks, and others. Four chief series are now distinguished: the principal P, the diffuse D, and sharp S series, and the fundamental (Bergmann) series F. Combination series 2P — 3S, etc., are also recognised. The lines may be single (then marked P, D, S, F) or doublets or triplets (marked *p, d, s, f.*) All the series are inter-related, S more to P, F more to D. The separation in doublets is constant in the D and S, but decreasing in the P and F series as the limit in the ultra-violet is approached, where all the lines become crowded. For the same group of elements the separation between the components of a doublet is proportional to the square of the atomic weight, and hence increases, *e.g.*, in the order Mg, Ca, Ba, Sr. The satellites further complicate spectra; in the series of Ca the triplet is well defined; in the D series the chief member is slightly shifted, the satellite occupying the normal position. In the enhanced lines of spark spectra some new lines appeared intensified while others dropped out. To account for these Bohr had replaced Rydberg's constant N by $N_1 = 2^2N$, and we might have to go further and introduce $N_2 = 3^2N$, the multiples of N being connected with the multiple charges on the particles. Concluding, Fowler remarked that many spectra do not show any regularity so far; also none of the formulæ is absolutely accurate except those for the Balmer series of hydrogen and the enhanced (Fowler) series of helium. But the chief thing to explain is why the wave number always comes out as a difference of two terms, one of which is the limit of the series (which generally appears as a term of another series) and the other is a function of N. **J. W. Nicholson**, dealing with the theory, said that the chief difficulty even with a theory like Bohr's was the lack of definiteness of the dimensions of the atom as regards the radii of the electron orbits. Bohr, moreover, could not explain the endless numbers of lines of Hicks and others, and the observations agree with ν where theory agrees with ν^2. But Bohr's atom has accounted for many peculiarities in the spectra of hydrogen and helium, and his ideas have been modified and generalised by Sommerfeld for non-circular orbits, thus explaining the fine-line spectra. Nicholson proceeded to show how Bohr had applied the quantum relation to spectra, and how he has explained the discrepancy which arises from the fact that a nucleus carrying several charges, in equilibrium with all its electrons, would not be in equilibrium when one of them was expelled, the whole then forming a system rotating about a common centre. Paschen has shown that the satellites become more complex with increasing atomic weight, which fact can be explained if the sum of three terms in the energy equation remains constant. Epstein has accounted for the Stark-effect on the quantum theory, and Stark himself has verified some of Epstein's further conclusions. But we do not understand as yet why certain components fluctuate in intensity, and so far the mathematical difficulties of "quantising" the spectrum are too great. **W. H. Bragg** considered the hypothesis (of Kossel and Lewis) of regarding the electrons as grouped in stationary positions as being more acceptable to chemists, and as fruitful as Bohr's theory, and he indicated the bearing of this hypothesis on spectroscopy. **A. E. Oxley** referred to the magnetic properties of hydrogen and helium. The hydrogen atom should be paramagnetic, and Hatfield had found that Mn fused in a hydrogen atmosphere was paramagnetic. But the hydrogen molecule, which on Bohr's theory might be represented as consisting of two nuclei with two electrons rotating in a vertical plane between the two, should also be paramagnetic, whilst Onnes found liquid hydrogen diamagnetic. It was similar with helium. Bohr's model could not be accepted, whilst Bragg's theory accounted for the magnetic properties and also for the ν instead of ν^2. Nicholson replied to this objection that the orbit of the hydrogen electrons need not be circular; the electrons might oscillate up and down in a line or describe contracted paths. A. W.

1599. *Excitation of Hydrogen Spectra by Slow Canal and Kathode Rays.* **M. Weth.** (Ann. d. Physik, 62. 7. pp. 589–602, Aug. 4, 1920. Dissertation, Greifswald.)—Investigation of the light emission by the slow-moving canal rays in the discharge between a pointed anode and a relatively large plate for kathode furnished information with reference to the carriers for the spectra of hydrogen. A new form of anode was used for this work, generally consisting of a copper wire, about 1·5 mm. thick, fused into glass tubing so as to have merely the end of the wire free. Spectro-analytical investigation of the discharge established Stark's theory relating thereto, in particular showing the existence of the canal rays by means of their Doppler-effect. The continuous hydrogen spectrum was observed with great intensity. The results, together with the observations made by Dempster, show that the Balmer series is emitted by positively-charged hydrogen atoms. A. W.

1600. *Extension of the Balmer Series, and Spectroscopic Phenomena of very long Vacuum Tubes.* **R. W. Wood.** (Roy. Soc., Proc. 97. pp. 455–470, Aug. 3, 1920.)—The difficulty of observing the lines of the Balmer series of hydrogen beyond the 12th member is due to the fact that the lines are so faint that, under ordinary conditions in vacuum tubes, they are completely masked by the continuous background and by the numerous lines of the secondary spectrum. By using a new type of very long vacuum tube the author has been able to eliminate almost completely both the continuous background and the secondary spectrum lines, so that photographs of the Balmer series as far as the 20th line, the intensity of which is probably less than one-millionth that of H_α, were obtained with an exposure of only half an hour in the third-order spectrum. The tube used had a central straight portion about 40 cm. long, which is used in the end-on position. At the ends of the straight portion were right-angled bends which are about 80 cm. from the two electrodes. The bore was about 7 mm. The precise form of the tube is immaterial, the essential point being the straight central portion at least 80 cm. from the electrodes. One end of the tube was permanently connected to a pump, while hydrogen was fed continuously into the other end, either moist, from the electrolysis of phosphorus pentoxide, through a long and very fine capillary tube, or dry, through a Pd tube heated by a small hydrogen flame. The appearance of the tube was remarkable, the colour of the discharge being bluish-white to a distance of about 50 cm. from each electrode, while the central portion gave a most intense fiery purple light. This central portion gave a very faint secondary spectrum, having, under the best conditions, an intensity about 1/40th that found with ordinary tubes. The lateral branches show the secondary spectrum as well as the Balmer lines, and it is only at a distance of about 50 cm. from the electrode bulbs that the secondary spectrum begins to vanish. Under the best conditions as regards pressure, etc., 20 lines of the Balmer series have been photographed. Unless the pressure is right, it is difficult to get beyond the 16th line. The correct pressure is such as to give a Crookes' dark space of about 6 mm. If the pressure is gradually raised, the higher members disappear in succession, as they should on Bohr's theory. If the pressure is lowered, they also disappear, though in this case their disappearance seems to be due to a development of a continuous spectrum and the enhancement of the secondary spectrum. A table is given of wave-length measurements for the 12th to the 20th line, with Dyson's values for solar hydrogen for comparison. No attempt was made to secure great accuracy; this will be carried out later. Intensity measurements showed that in the region between the 6th line and the 14th line each line was very nearly twice as bright as its neighbour on the short wave-length side. It seems that beyond the 14th the rate of decrease becomes less, the three lines before the 20th being of not very different intensity. The 20th line thus has an intensity of something like 1/600,000 that of H_α.

Discharge phenomena in very long tubes.—The phenomena observed with long discharge tubes are described at some length. A new tube has to be operated for some time before the desired results (as regards the central portion of the tube) are obtained. Under certain conditions of operation the Balmer series could be suppressed, the central portion giving practically nothing but the secondary spectrum. It appears to be well established that pure dry hydrogen gives only the secondary spectrum at any great intensity, and that for the strong development of the Balmer series, a trace of water-vapour is required. It was found that the same thing could be accomplished with oxygen. Experiments have also been made with helium and with oxygen in the long tube, but the results are still incomplete. A. W.

1601. *Dissociation and Fluorescence of Iodine Vapour.* **St. Landau and E. Stenz.** (Phil. Mag. 40. pp. 189–197, Aug., 1920.)—R. W. Wood's researches on the fluorescence of the vapours of sodium, mercury, and iodine are well known. The most complicated relations were found in the case of iodine vapour [Abs. 375 (1918)]. The number of lines in the absorption spectrum of iodine is estimated by Wood to be 40,000–50,000. Different resonance spectra are obtained when the exciting line covers different absorption lines. The question arises as to whether the complicated vibrating system, which corresponds to these various resonance spectra, belongs to the atom or to the molecule. Experiments are described which show that rise of temperature does not produce so much effect on the fluorescence of iodine vapour as has hitherto been thought. The fluorescence was observed at temperatures above 800° C. Other experiments showed that dissociation destroys the fluorescence and the resonance spectra. Thus the complicated vibrating system corresponding to the thousands of absorption lines in the visible part of the spectrum belongs to the molecule, and not to the atom of iodine. The structure of the atom should be relatively simple. The results obtained are in accord with other facts relative to the fluorescence of vapours. Monatomic mercury vapour gives a simple resonance; the complex fluorescence spectrum of sodium vapour has been shown by Dunoyer to be due to impurities; pure sodium gives the D-lines only. It also seems extremely probable that the absorption lines which are so characteristic of diatomic iodine and so sensitive to the action of monochromatic light, do not belong to the absorption spectrum of monatomic iodine. A. W.

1602. *Quantum Theory of the Many-lined Spectrum of Hydrogen.* **M. Wolfke.** (Phys. Zeits. 21. pp. 407–410, Aug. 1, 1920.)—Stark has shown that the carrier for the many-lined spectrum of hydrogen is the positive molecule-ion H_2^+ [Abs. 637 (1917)], and in the present paper it is shown that by applying Bohr's quantum hypotheses not directly to the neutral hydrogen molecule, but to the positively charged molecule, and following Debye's model of the hydrogen molecule, it is possible to account for many thousands of lines in the visible, ultra-violet and Schumann regions of the spectrum. A. W.

1603. *Analysis by X-rays.* **W. H. Bragg.** (Röntgen Soc. J. 16. pp. 127–133, Oct., 1920. Engineering, 109. pp. 365–366, March 19, 1920. Silvanus Thompson Memorial Lecture.)—After a brief historical review in which reference is made to the early work of Laue and of the author, details are given of recent methods of chemical analysis by means of X-rays. First of all a method due to de Broglie is dealt with. In this method the limiting absorption frequencies of the elements give the clue to their atomic weight (Moseley's law gives the required information). This method has been developed by de Broglie, who has used it as a refined method of qualitative chemical analysis. A second method developed mainly by Debye on the Continent and by Hull and others in America is a modification of the Bragg method and is applicable to crystalline substances in pulverised form. This powder is placed in a cylinder of very thin glass or celluloid so as to form a thin rod about 1 mm. in diam. and 10 mm. in length (Debye). When a fine beam of monochromatic X-rays is sent through the substances it will meet crystals at every orientation, their distribution being entirely at random. There will be a certain number of crystals whose faces make the proper angle θ with the incident rays to reflect the particular rays used; they will not reflect any rays at other angles. The beam of X-rays is made to fall on the middle of the rod, the reflected rays falling on a cylindrical photographic film coaxial with the rod. A system of rings characteristic of the crystal is thus obtained. No two crystal-forms give the same system of rings, and when the powder is made up of a mixture of different crystals each will give its own system of rings. Employing this method, Debye showed that graphite and "amorphous" carbon have the same crystal structure, and hence there are only two (not three) allotropic modifications of carbon. Salt mixtures have been qualitatively analysed by this method, which is capable of discriminating, for example, between a mixture of (NaCl + KF) or of (NaF + KCl) in the presence of other alkali salts. Such analysis is extremely difficult by chemical methods. The X-ray method of analysis has been extended also to ascertaining whether the carbon existent in an alloy, for example, is present in the free state, or is combined as a carbide of the metallic constituents of the alloy. A. B. W.

1604. *The K-Characteristic Absorption Frequencies for the Chemical Elements Magnesium to Chromium.* **H. Fricke.** (Phys. Rev. 16. pp. 202–215, Sept., 1920.)—*Absorption of X-rays.*—An account of an experimental investigation concerning the discontinuity in the X-ray absorption corresponding to the K-series for the chemical elements from magnesium to chromium inclusively. The method followed was the same as that devised and employed by de Broglie. A specially designed vacuum spectrograph was used.

Fine structure of absorption.—The spectrograms show that the discontinuity has a rather *complex structure*, a result in advance of those obtained by earlier investigators. A *photometric study* of the plates was made in order to obtain a more accurate knowledge of the detailed structure of the absorption limits.

Results.—These are recorded in tables which give for each element the wave-lengths of the different remarkable points in the structure of the discontinuities. The theoretical bearing of the new observations is briefly discussed. AUTHOR.

1605. *Mathematical Process for use in X-ray Spectrum Research.* **H. Kröncke.** (Phys. Zeits. 21. pp. 220–223, April 15, 1920.)—A description is given of a simple mathematical process to be applied in the analysis of X-ray spectra. A. B. W.

RADIO-ACTIVITY.

1606. *Distribution of Intervals of Emission of α-particles from Polonium.* **[Mme.] P. Curie.** (J. de Physique et le Radium, 1. pp. 12–24, Jan.–July, 1920.)—The experiments now described arose out of a long series of investigations, on polonium, carried out by the author in collaboration with Debierne. The work had for its object the preparation of a strong source of polonium, the determination of its spectrum, the investigation of its eventual transformation into lead, and the determination of Avogadro's constant by measuring the volume of helium corresponding to a known number of α-particles emitted by the active matter. A joint publication of the results of this work is promised. The main results obtained before 1914 were published by Debierne (Thesis, Paris, 1914), who gave, amongst other important information, the first value of Avogadro's constant obtained by the new method, namely, $6{\cdot}5 \times 10^{23}$, a value to be followed later by more exact determinations. The counting of the α-particles involved in this investigation was carried out by an automatic method of registration (due to Rutherford and Geiger).

An analysis is now given of the photographic records obtained, in which over a million α-particles were counted. A theoretical discussion as to the law of distribution of time intervals precedes a series of tabulated results. It is clearly demonstrated that the experimental law of distribution of 10,000 intervals completely verifies the theory deduced from the law of chance. This verification is all the more striking when it is considered that a correction has to be made for the decay of the active source with time. The paper concludes with a determination of the decay constant of polonium—this value having been found with great accuracy in the above experiments. Thus:

$$\lambda = 0{\cdot}00496 \text{ day}^{-1}$$
$$T = 202 \text{ days}$$

A. B. W.

1607. *The Geiger-Nuttall Equation.* **G. Kirsch.** (Phys. Zeits. 21. pp. 452–456, Sept. 1, 1920.)—The empirical relation, obtained by Geiger and Nuttall, connecting the decay constant λ and the range R of α-particles emitted by a radio-active substance is given by the formula $\log \lambda = A + B \log R$. Lindemann [Abs. 1684 (1915)] has given theoretical justification for this relation, assuming that the particles oscillate with a mean energy $E = h\nu$. Every particle passes a critical state ν times per sec., so that the probability of its presence in this critical condition in a time interval τ is $\tau\nu$. For N independent particles therefore $\lambda = (\tau\nu)^N$ whence $R = kE^{3/2}$ and $\log \lambda = Na + \frac{2}{3}N \log R$, where $a = \log (\tau/hk^{2/3})$.

For the Uranium series	N = 81
,, Thorium series	N = 77
,, Actinium series	N = 71

Employing the Geiger-Nuttall relation as modified by Lindemann, the author makes interesting deductions relating to the nuclei of the atoms emitting α-particles.

A. B. W.

1608. *Law of Range of α-particles.* **H. T. Wolff.** (Phys. Zeits. 21. pp. 393–396, Aug. 1, 1920.)—Carruthers has found [Abs. 335 (1916)] that the logarithm of the range of α-particles for each group of isotopes is approximately a linear function of the log. of the atomic weight of the bodies emitting the α-particles. The author now gives a simple relation determining the range for each radio-active series. Instead of the atomic weight, the difference $(k - s)$ is employed, where k is a constant and s is a certain number indicating the position of the substance (emitting the α-particles) in the series of decay. The general equation is

$$\log R = x \log (k - s) + y,$$

where x is a negative and y a positive constant.

For the Th series	$\log R = -6{\cdot}844 \log (58 - s) + 12{\cdot}476$
Ur to Ra ..	$\log R = -3{\cdot}183 \log (60 - s) + 6{\cdot}033$
RaEm to RaC′	$\log R = -6{\cdot}629 \log (54 - s) + 12{\cdot}081$
Ac series ..	$\log R = -6{\cdot}777 \log (55 - s) + 12{\cdot}291$

The value of k for Ur and Th is shown to be one-quarter of the atomic weight.

A. B. W.

1609. *Practical Determination of Radio-activity of Spring-Waters.* **O. Nürnberger.** (Phys. Zeits. 21. pp. 241–245, May 1, 1920.)—The author refers to the work of Mache and Meyer, Engler and Sieveking, H. W. Schmidt, Wulf, Kohlrausch, and others on this subject, and deduces certain general observations from a collection of their experimental results. The rise curve of natural mineral waters shows systematic deviations from that of a pure emanation solution; these deviations, characteristic of each spring, probably depend on the salt- and gas-contents of the water.

The separate determination of the active deposit leads to defective results which vary considerably according to the experimental conditions. In none of the apparatus used in the measurements to which the author refers is the applied potential sufficient to ensure complete saturation.

A. B. W.

1610. *Measurement of Radium Emanation in Spring-Waters.* **H. Greinacher.** (Phys. Zeits. 21. pp. 270–272, May 15, 1920.)—Describes a method of determining radium emanation in samples of spring-water using the "Fontaktometer" [see Abs. 898 (1909)]. Correction factors depending on the dimensions of the measuring vessel are considered.

A. B. W.

HEAT.

1611. *Conductive Cooling in Coal-Gas and Air Explosions.* **W. T. David.** (Phil. Mag. 40. pp. 318–326; Sept., 1920.)—The gaseous mixtures were exploded in a cylindrical cast-iron vessel. The pressures on firing were measured by a Hopkinson optical indicator, giving continuous curves from which the mean temperatures were calculated from the equation $pv = R\theta$, after allowing for a small contraction taking place during combustion. The heat loss by conduction was measured by means of a grid of highly polished silver mounted upon a backing of linoleum placed on one of the end covers, the curve of resistance increase of which was traced, by means of a reflecting galvanometer, upon the same photographic film as the pressure curve. Subsidiary experiments suggested that the indication of the large grid covering the upper half of the end cover might, without serious error, be taken as giving the mean value of the conduction loss over the entire surface of the vessel. A number of tables are given and the corresponding curves reproduced in the paper. The proportion of heat of combustion lost by conduction to the vessel up to the moment of maximum temperature was much greater the weaker the mixture, owing to the greater time of explosion. The weaker mixtures, in the initial stages of cooling, lost heat by conduction rather more rapidly than the stronger mixtures when they had cooled to the same mean temperatures as the weaker ones had in this epoch, as was found to occur in the radiation losses [see Abs. 1703 (1911)]. This was probably due mainly to convection currents, which, having been set up during the explosion period, are more vigorous in the initial stages of cooling than in the later ones. Where $\dot{C}$ is the rate of loss by conduction in calories per sq. cm. of wall surface per sec., θ the mean absolute temperature of the gaseous mixture, and θ' the absolute temperature of the vessel, taken as 300° in these experiments, it was found that $\dot{C}$ is proportional to the fifth power of $\theta - \theta'$ near 2400° C. abs., to the 4th near 2100°, to the cube near 1800, and to the square near 1500°. At still lower temperatures $\dot{C}$ would probably be proportional simply to $\theta - \theta'$. The combination of the results of these experiments and the radiation experiments previously referred to will be effected in a subsequent paper, and will give the total loss of heat during explosion and cooling. Hence can be estimated the internal energies of the mixtures employed in terms of the gas temperature. G. W. de T.

1612. *Selective Reflection of Heat Waves by Linear Resonators.* **E. C. Wente.** (Phys. Rev. 16. pp. 133–148, Aug., 1920.)—*Vacuum thermo-couple.*—The construction of a vacuum thermo-couple of high sensitivity and quick action for measuring heat radiation is described.

Isolation of long heat waves.—A method is given for isolating radiation of great purity and having a mean wave-length of 96 μ. This radiation is obtained by combining a quartz-lens focal isolation apparatus with reflecting surfaces of potassium iodide.

The reflection of radiation by linear electric resonators of microscopic dimensions.—Resonators were ruled for films of silver chemically deposited on glass plates. The reflecting power of such resonators was measured for the 96 μ waves. Square resonators, the length of whose sides are small compared with the wave-length reflect little more than bare glass, provided the resonators are separated sufficiently to prevent conduction between adjacent edges. Resonators of equal width and separated by a distance of approximately one half wave-length were found to produce a maximum reflection when their length was equal to 0·3 of the wave-length. The metal strips, although microscopic in size, thus show electrical resonance when stimulated by long heat waves. The results are in every way comparable with those that have been obtained with the longer electric waves. AUTHOR.

1613. *Convection of Heat by Uniform Stream of Liquid.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 2. pp. 140–153, July, 1920.)—A continuation of previous work on this subject by Boussinesq [Abs. 761 (1905)] and King [Abs. 1993 (1914)], where the assumption is not made that $n = VC/2\kappa$ is large, V, C, and κ being respectively the stream velocity, the specific heat, and the thermal conductivity of the fluid. J. W. T. W.

1614. *Variation of Specific Heat of a Gas with Temperature.* **G. W. Todd.** (Phil. Mag. 40. pp. 357–362, Sept., 1920.)—The criticisms which are frequently brought up against the principle of the equipartition of energy among the degrees of freedom of the molecules of a gas are the experimental observations (*a*) that the molecular heat varies with the temperature when it should be $C = \partial/\partial\theta(\frac{1}{2}n/R\theta) = \frac{1}{2}nR$, and (*b*) that the ratio of the specific heats of a gas also varies with the temperature when it should agree with the equation $\nu = 1 + 2/n$, n being the number of degrees of freedom. It is often argued that since we cannot have a fractional degree of freedom, then if C and ν do change with temperature, the changes should take place in steps.

It is shown in the paper that the criticisms are unjust, and that the principle will account for the available experimental facts, as well as does the quantum theory which discards altogether the equipartition principle. The specific heat at constant volume is first considered, the method of treatment adopted being as in previous papers [see Abs. 767 (1919)], in which gas molecules are assumed to have 3 degrees of freedom so long as their velocities are below a critical value. Above this critical value the collisions are assumed to produce added degrees of freedom (*e.g.*, rotation). Agreement with Eucken's experimental results for the molecular heat of hydrogen at low temperatures is seen to be good. The development of further degrees of freedom would explain Bjerrum's values for hydrogen at very high temperatures. The ratio of the specific heats is next considered. Unfortunately hydrogen is the only gas for which there are experimentally determined values of the molecular heat at low temperatures, so that experimental data are awaited to establish the sufficiency of the kinetic theory for other gases and whether any relations exist between their chemical energies and their physical or chemical properties. H. H. Ho.

1615. *Electrical Methods of Measuring Body Temperatures.* **R. S. Whipple.** (Inst. El. Eng., J. 57. pp. 1–9; Disc., 9–12, April, 1920. Supplement. Electrician, 82. pp. 375–376; Disc., 376, April 4, 1919. Abstract.)—The paper describes methods of recording body temperatures with an accuracy of about 1/100th of a degree C. Copper-constantan thermo-couples as well as Pt-resistance thermometers are used. The thermo-couples are made of 0·1-mm. diam. wires mounted between two pieces of canvas embedded in rubber and vulcanised. The approximate dimensions of the couple are 50 mm. × 5 mm. × 2·5 mm., the couple, or junction of the two wires, being exposed on the surface of the rubber. Stouter wires are soldered to the fine couple wires, and these in turn are attached to the leads connected to the recording galvanometer. The resistance thermometers consist of a fine Pt wire, 0·05 mm. diam., 140 ohms in resistance, wound on a mica frame in the form of a cross, the coil on its frame being enclosed in a silver tube.

The thermometer coil is connected by comparatively heavy copper leads to a Wheatstone bridge in the usual manner. Two types of recording apparatus have been tried—the photographic recorder and the thread recorder. The photographic method is the more accurate, but it is too cumbersome for ordinary work, so the thread recorder is generally used. It consists of a moving coil suspended between the poles of a permanent magnet. A pointer is attached to the coil and overhangs the paper on which the record is to be made. This paper is wrapped round a drum which rotates by clockwork once in 25 hours. Immediately over the paper an inked thread is stretched parallel to the axis of the drum. A presser bar is placed above the galvanometer pointer and this bar is normally held free of the pointer by means of the cam mounted on a shaft. Every minute the cam makes half a revolution allowing the presser bar to fall upon the pointer and raising it again to its normal height. As the presser bar falls it depresses the pointer on to the drum, nipping the inked thread between the pointer and the paper and thus producing a dot.

With the thermo-couple it is necessary to keep the cold junction at a steady temperature by immersion in a thermostatically controlled water-bath maintaining a temperature of 36·5° C. (98·4° F.). E. G.

1616. *Radiometer Forces and Ehrenhaft's "Photophoresis."* **A. Rubinowicz.** (Ann. d. Physik, 62. 8. pp. 691–737, Aug. 20, 1920.)—A comprehensive mathematical treatment of radiometer forces and of the motion of illuminated particles ("photophoresis"). The approximate formula obtained for radiometer forces gives results in general agreement with the experimental values obtained by Ehrenhaft and I[rene] Parankiewicz [Abs. 1085 (1918) and 425 (1919)] for the motion of illuminated particles. A. W.

1617. *Reduced Transformation and Fusion Temperatures.* **J. Narbutt.** (Phys. Zeits. 21. pp. 341–349, July 1, 1920.)—If the entropy S in a condensed single substance system be assumed to conform to the equation $S = (U - A)/T = bT + cT^2$, where U is the total energy, A the free energy, T the absolute temperature, while b and c are constants, then $A = -\frac{1}{2}bT^2 - \frac{1}{3}cT^3 + \text{const.}$ by integration from $-dA/dT = bT + cT^2$. For $T = 0$, const. $= A_0 = U_0$, and therefore $A = U_0 - \frac{1}{2}bT^2 - \frac{1}{3}cT^3$, whence $U = U_0 + \frac{1}{2}bT^2 + \frac{2}{3}cT^3$. The last two equations, which correspond to the Nernst equations, are now modified slightly and applied to the transformation of enantiotropic solid bodies, *e.g.*, the solidification of fused substances. It is shown that at equal reduced temperatures, the ratio of the transformation (*i.e.*, solidification) affinity, to the heat of transformation at the fusion temperature is the same for all substances. Also that the ratio of the heats of transformation in the two directions at the fusion temperature is the same for all substances. Tables of results are given for benzol, water, *p*-chlor-brom-benzol, *p*-dichlor-benzol, *p*-dibrom-benzol, *p*-brom-iodo-benzol, and *p*-di-iodo-benzol. Dissimilar substances such as sulphur, magnesium chloride, and cobalt nitrate are then discussed. The quotient of the transformation (*i.e.*, solidification) affinity, also of the heat of transformation, and the transformation temperature (*i.e.* fusion temperature) are next shown to be the same at equal reduced temperatures for all substances with equal entropy values. It is established that the heat of transformation may be calculated from the vapour pressures of the supercooled liquid and solid bodies, *i.e.*, of the labile and stable modifications; also the vapour-pressure curve of a supercooled liquid may be found when that for the solid substance is known, or conversely. Similar relationships hold with respect to the vapour pressures of undercooled liquid and solid substances as for heats of transformation. H. H. Ho.

1618. *The Radiation-Pressure at a Circular Cylinder of any Given Material.* **G. Thilo.** (Ann. d. Physik, 62. 6. pp. 531–568, July 16, 1920. Dissertation, Breslau.)—The problem of the diffraction of plane, electromagnetic, polarised waves at circular cylinders has already been investigated by Ignatowsky [see Abs. 134 (1906)], Seitz, and Schaefer and Grossmann. The present paper deals with the radiation-pressure exerted by a plane-polarised electromagnetic wave upon an infinitely long circular cylinder, Part I containing the case where the electric force is polarised parallel to the cylinder axis and Part II the corresponding perpendicular case. The dielectric constant ϵ, the permeability μ, and the conductivity σ of the cylinder may have any given values. An exact formula for the radiation-pressure is derived which holds essentially unchanged, not only for one but for any coaxial cylinder, the coefficients, however, being more complex. The radiation-pressure has been calculated in the case of a water cylinder of 1 cm. radius for 50 different lengths of the incident waves from $\lambda = 125 \cdot 6$ cm. to $\lambda = 3 \cdot 7$ cm., in order to discover its relationship with the special oscillations of the cylinder. Within this interval a strong reinforcement of the radiation-pressure is shown to be produced by these special oscillations, the pressure acting in the direction of propagation of the incident wave. In an appendix to the paper the formula is derived for the field disturbed by two coaxial cylinders. Numerous diagrams are included. The paper is mathematical throughout. H. H. Ho.

1619. *The Liouville Hypothesis and the Relativity Theory.* **E. Kretschmann.** (Phys. Zeits. 21. pp. 484–487, Sept. 15, 1920.)—The definition of the entropy S of a physical system by the probability W of its state, is based on the validity of the Liouville hypothesis, $S = k \log_e W$. It is therefore an important question whether this hypothesis is still valid in the mechanics of the relativity theory, where in place of the instantaneous acting forces, only forces can occur which are propagated through space with the velocity of light. This problem has not yet been investigated, although Jüttner [see Abs. 848 (1911)] has transformed the above thermodynamical expression for an ideal gas into its corresponding form on the relativity theory. It is shown in the present paper that for a large class of force laws appreciable deviations from the Liouville hypothesis exist on the relativity theory. H. H. Ho.

1620. *A Vapour-pressure Equation.* **C. H. Meyers.** (Phil. Mag. 40. pp. 362–363, Sept., 1920.)—This is a note on a paper by G. W. Todd and S. P. Owen [see Abs. 240 (1920)] in which was developed the equation $N_v = N_1 e^{-B/\theta}(1 + B/\theta)$, and, from the fact that $N_v \propto p$ and $N_1 \propto \varrho$ at a given absolute temperature, the deduction was made that $p = A\varrho e^{-B/\theta}(1 + B/\theta)$. Since p is a function of both N_v and θ, while ϱ is a function of N_1 only, A must be a function of θ. The first equation above can then be put in the form $\varrho_v = \varrho_1 e^{-B/\theta}(1 + B/\theta)$, where ϱ_1 and ϱ_v are the densities of liquid and vapour respectively. Since $B = mc_1^2/2R$, and $\varrho_v = \varrho_1$ at the critical temperature, it follows that at this temperature $mc_1^2/2R = 0$. Hence c_1 must be a function of the temperature and cannot bear a definite relation to the molecular velocity at the critical temperature. The agreement of the equation deduced with observed data cannot therefore be considered as justifying the original assumptions, since additional assumptions are introduced. Considering the equation purely as an empirical one, the agreement with observation does not appear sufficiently good to make it of value. H. H. Ho.

1621. *Notes on the Expansion of Saturated Vapours.* **G. Bruhat.** (Comptes Rendus, 171. pp. 162–164, July 19, 1920.)—The slope of the adiabatics is first considered, and it is shown that during adiabatic expansion of a saturated vapour dv/dp is always negative, while the adiabatic of the gas always makes a smaller angle with the pressure axis than the adiabatic of the mixture. The critical adiabatic is next investigated, and found to make a finite angle with the saturation curve, and to undergo a finite refraction. The value of m^1, the specific heat of a saturated vapour, is then considered remote from the critical point. Comparing the vapour with a perfect gas, m' is found to be equal to $-L_0 + \int_0^T C\,dT/T$. For $T = 0$, $m' = -\infty$; m' increases with T, and vanishes for $T = \theta$ if $\int[0, \theta]C\,dT$ attains the value L_0; that is, $L_0 = C'\theta$. Data are given for sulphur dioxide, chloroform, and benzene, from which it is seen that the above expression represents the variation of m' as far as the neighbourhood of the lower inversion point. The paper concludes with a note on the refraction of the adiabatics at very low temperatures. H. H. Ho.

1622. *Third Law of Thermodynamics.* **G. N. Lewis and G. E. Gibson.** (Am. Chem. Soc., J. 42. pp. 1529–1533, Aug., 1920.)—The third law of thermodynamics as stated by Nernst requires that any entropy change involving solids and liquids vanishes only at the absolute zero of temperature. Planck has shown, however, that this must be modified in cases of solution, and assuming for convenience the zero entropy being taken such that the entropy of every element vanishes at absolute zero, he modifies the statement of Nernst into: the entropy of any pure substance is zero at the absolute zero. The author's earlier experiments [Abs. 177 (1918)] confirm the validity of the law for pure crystals, but no experiments have been published on the behaviour of solutions at low temperatures.

But in general, as the authors here show, the entropy change in a process of solution cannot be expected to vanish at the absolute zero. In the extreme case of a mixture of two isotopes, having both the same atomic number and the same atomic weight, it seems hardly conceivable that they should undergo any measurable change in heat capacity on mixing, so we are driven to conclude that the entropy change on mixing remains essentially constant down to the absolute zero. Moreover, the specific heat of ordinary lead, which may be regarded as a solid solution of mixed isotopes, behaves at low temperatures exactly as would be expected from the behaviour of other metals. Therefore if zero entropy be assigned to the pure substances, it cannot also be assigned to their solutions. But the distinction between pure liquid and solution is somewhat artificial. Water probably consists of several molecular species, including simple molecules, types of associated molecules, H and hydroxide ions; yet it is regarded as a pure substance in that at ordinary temperatures equilibrium is established in an imperceptibly small time. This might not be so at such low temperatures that the molecular species could behave as independent constituents of a mixture. Liquid sulphur at high temperatures has entirely reproducible properties, but at lower temperatures behaves as a mixture of S_λ and S_μ, say, which are transformable into each other only slowly. One is soluble in carbon disulphide and the other not, and when pure crystalline sulphur is melted it produces pure liquid S_λ, the melting-point of which is lowered by admixture of S_μ, involving an increase of entropy. If this mixture, and also pure S_λ and S_μ could be observed during super-cooling we should undoubtedly find at least part of this entropy persisting to absolute zero, so that if zero entropy be assigned to S_λ and S_μ we cannot assume zero entropy for the mixture. Even if a substance consist of a single molecular species, amorphous or a super-cooled liquid, there appears no reason, theoretical or experimental, for its inclusion within the scope of Nernst's third law. Now in many cases of crystalline solids the law is verified experimentally, and from the standpoint of statistical mechanics is essentially a consequence of the laws of probability, so that a relation is to be anticipated between the entropy of a substance in a given state and the probability of the molecular arrangement constituting the state. Now in a crystal there is no randomness of arrangement, but there is some even in a pure liquid or glass; in a solution there is a random distribution of several types of molecules; and in any substance at a finite temperature there is a random distribution of energy among the individual molecules. The author therefore concludes that the entropy of a perfect crystal of a pure substance vanishes at the absolute zero, and suggests a re-statement of Nernst's third law in the form: *If the entropy of each element in some crystalline form be taken as zero at the absolute zero, the entropy of any pure crystal at the absolute zero is zero, and the entropy of any other substance is greater than zero.* G. W. de T.

SOUND.

1623. *Maintenance of Oscillations by means of Valves.* **H. Abraham and E. Block.** (J. de Physique, 9. pp. 225–233, July, 1920.)—This paper describes valve arrangements for maintaining the oscillations of a pendulum or the vibrations of a tuning-fork. The pendulum carries a horse-shoe magnet at its lower end, the limbs of the magnet being horizontal and in the plane of the pendulum's motion. As the pendulum oscillates the magnet poles move in and out of two coils (of about 10,000 turns each), one of which is included in the grid circuit of a valve and the other in the anode circuit. If the coils are connected up in the proper sense, the oscillations of the pendulum will be maintained. If the sense is reversed the oscillations will be damped out more rapidly than without the valve attachment. Arrangements are described in which two valves are used, with resistance–capacity coupling between the valves. For the maintenance of the vibrations of a tuning-fork, two electromagnets are mounted near the ends of the prongs. Two telephone receivers of about 2000 ohms' resistance, with diaphragms and covers removed, are suitable for this purpose. These are supported outside the prongs and their distance from the prongs can be adjusted by means of screws. One of the telephones is connected to the input terminals of a 3-valve amplifier with either transformer or resistance–capacity coupling between the valves, and the other telephone is connected to the output terminals of the amplifier. If the connections are right the vibrations of the fork will be maintained; if then the connections to one telephone are reversed, the vibrations will be more rapidly damped than usual. A. W.

1624. *Variably Coupled Vibrations: Gravity Elastic Combinations. II. Both Masses and Periods Unequal.* **L. C. Jackson.** (Phil. Mag. 40. pp. 329–342, Sept., 1920.)—In a previous paper [Abs. 894 (1920)] the author described a model of a coupled system consisting of a gravity pendulum and an elastic pendulum, the separate periods and the masses of the two being equal. In the present paper the mathematical theory of a coupled system consisting of a gravity and an elastic pendulum is developed for the general case, in which the masses and periods of the two pendulums are both unequal. A detailed description of the apparatus employed is given. The model may be considered as analogous to the case of coupled electric circuits, in which the inductances and periods both are different. The apparatus, though still the same in principle, has been entirely re-made and improvements effected in certain details. The chief points in which the present apparatus differs from the one previously described are such that simultaneous traces of the motion of each bob can now be obtained on the same photographic plate. As the traces show that the damping for the present arrangement is not negligible, it was thought desirable to take this into account in the theory. The paper includes 24 photographic reproductions of the double traces obtained for the motions of the bobs under various conditions of starting and coupling. One set of figures shows component vibrations, the frequencies of which are very nearly 2 : 1 with the characteristic kink of the 2 : 1

curve showing plainly. Another set shows clearly the phenomenon of beats with a progressive increase in the difference between the frequencies of the component vibrations. A third set shows the dependence of the traces on the initial conditions, the trace of the bob which was started being in this case almost a simple sine curve throughout, while the other trace is complex. The figures show that the bob which is first started can have a very considerable amplitude of vibration without producing any great amplitude in the coupled vibration of the other bob.

A. E. G.

1625. *Audition through the Teeth.* **F. Piola.** (N. Cimento, 19. pp. 214–221, May, 1920.)—The audiphone gives feeble results. If the receiver of a telephone be modified so as to promote magneto-striction and to enable the hearer to grasp the core directly with his teeth, we then have the author's "magnetophone," which is a very powerful instrument. The receiver is put in circuit with a microphone and three dry cells. A. D.

1626. *Sound Pressure.* **E. Waetzmann.** (Phys. Zeits. 21. pp. 449–451, Sept. 1, 1920.)—An experiment is here described by which the beats of two separate sources of sound may be heard and, at the same time, the objective existence of sine-formed pressure components, of the same period as the beats, may be recognised. For the sources two tuning-forks are used, their prongs being near the open ends A and B of tubes which merge into a single tube at C. The single tube then continues some distance horizontally and near the end has a slight dip followed by a rise. In the two limbs of this dip a liquid is present so that a sensitive manometer is thus formed. [See Abs. 1182 (1920).] E. H. B.

1627. *Reed Pipes as Coupled Systems.* **H. Vogel.** (Ann. d. Physik, 62. 3. pp. 247–282, June 8, 1920.)—In this paper the attempt is made to regard a reed pipe as a coupled system consisting of the reed and the pipe. The less-damped of the two is regarded as the one that settles the pitch. In the neighbourhood of resonance of reed and pipe, where the dampings of the coupled systems are practically equal, unstable conditions of pitch must set in for tight couplings. Some details are worked out and graphs plotted. The apparent discrepancy between the views of Weber and Willis is also explained. E. H. B.

1628. *Forced Vibrations.* **E. Waetzmann.** (Ann. d. Physik, 62. 4. pp. 371–388, June 17, 1920.)—The special case is here considered of forced vibrations where the elastic system is under forces not strictly proportional to the displacement. To study these cases a loaded elastic membrane is set in vibration. Curves are given showing a number of the results thus obtained. The simple superposition (which is valid for elastic systems under forces proportional to the displacement) does not here hold good. The present cases are referred to as examples of distorted superposition [see Abs. 1702 (1913)]. E. H. B.

1629. *Detection of Submarines.* **H. C. Hayes.** (Am. Phil. Soc., Proc. 59. 1. pp. 1–47, 1920.)—An excellent and semi-popular account of the American work in this line carried out during the war. It is divided into thirty sections or subsections and is copiously illustrated by eighteen plates, many of which have several figures or diagrams. The microphones and their circuits are clearly shown in sections and diagrams, and the various listening devices are described in detail. But the fulness of illustration makes intelligible abstracting hopeless, apart from reproduction of the plates. The original should be consulted. E. H. B.

1630. *Attempt to reconcile Helmholtz's Theory of Combination Tones and R. König's Theory of Beat Tones.* **E. Waetzmann.** (Zeits. f. Physik, 1. 5. pp. 416–425, 1920.)—The author here puts forward a generalised theory which, it is claimed, embraces all the experimental data and effects the above-mentioned reconciliation between the theories of Helmholtz and R. König. [See next Abstract.] E. H. B.

1631. *Distortion of Vibrations by Asymmetrical Conditions.* **E. Waetzmann.** (Zeits. f. Physik, 1. 4. pp. 271–282, 1920.)—It is well known that vibrations are distorted by any asymmetry in the restoring forces corresponding to any displacement. These effects are here shown by reproductions of seven interesting traces obtained from microphone or telephone membranes. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1632. *Electromagnetic Force between Two Atoms.* **G. A. Schott.** (Phys. Rev. 16. pp. 162–164, Aug., 1920.)—Making use of results obtained in a previous paper giving the average radial repulsion exerted by a charge e on a charge e' when both charges are revolving in circular orbits at a great distance, the author obtains a formula for the force between atoms. He concludes, in reply to a criticism by A. C. Crehore: *In a passive neutral atom* the radial force vanishes completely. *When both atoms are ionised* there is a residual force, negligible in comparison with an electrostatic force which may be taken to represent the chemical force between the ions. *When one atom is neutral and the other ionised*, the electrostatic force vanishes, leaving a residual force, which is estimated to be too small to play anything but a very small part in chemical actions. AUTHOR.

1633. *Note on the Retarded Potentials.* **M. Mason.** (Phys. Rev. 15. pp. 312–316, April, 1920.)—*Electromagnetic Field Equations; Mathematical Theory.*—This note gives a *simple method of deriving the electromagnetic scalar and vector potentials.* From the field equations it follows in the well-known manner that these potentials satisfy the non-homogeneous form of the wave equation. This equation is reduced, in Poisson's manner, to one of two independent variables r, t, by introducing a function U which is the integral of the potential 0 over the surface of a sphere of radius r about the point at which the potential is sought, divided by r. The potential is given by the limiting value of U divided by r as r approaches zero. In the method of Abraham the equation is solved for U and the potential determined from U as indicated. It is, however, not necessary to determine U itself, but only the value of its derivative with respect to r for $r=0$, since this derivative gives the limiting value. It follows, after a change of independent variables in the equation for U, that a single integration determines the potential in a simple and direct manner. AUTHOR.

1634. *Electronic Theory of Electromagnetic Forces.* **E[lena] Freda.** (Accad. Lincei. Atti, 28. i. pp. 384–389, June, and 28. ii. pp. 20–24, July, 1919.)—A careful criticism of Righi's conclusions as to electromagnetic forces being due to electronic pressure followed by an investigation into the isothermic case (uniform number of positive and negative ions at all points of the conductor) and the modifications necessary on departure from this condition. A. D.

1635. *Unipolar Induction.* **W. F. G. Swann.** (Phys. Rev. 15. pp. 365–398, May 1920. Paper read before the Am. Phys. Soc.)—*Unipolar induction; theory of the uniform motion of a system of Ampèrian current whirls.*—The paper forms an inquiry as to the extent to which the so-called "moving-line theory" is the equivalent of the Maxwell-Lorentz theory. The latter gives the electric force on a fixed unit of charge in the form: $E = -1/c \,.\, \partial U/\partial t - \text{grad}\,\psi$, where U is the Maxwellian vector potential, and ψ is the electrostatic potential.

At first sight it might appear that ψ would be zero in the case of a *magnet which was uncharged when at rest*. It is shown, however, that the mere fact of the absence of resultant force upon a charge which accompanies a magnet in uniform rectilinear motion requires a rearrangement of electric density in the Ampèrian whirls (or their equivalents) which constitute the molecular magnets, *and, this rearrangement is such as to endow the magnetic doublets with the properties of electric doublets as well*, the axes of corresponding magnetic and electric doublets being perpendicular to each other. These electric doublets result in a *finite value for* ψ. *It appears that, when* ψ *is included in this way, the Maxwell-Lorentz theory is the equivalent of the "moving-line theory"* for the case of a single magnetic doublet in uniform motion.

Application to rotating magnetic systems, and relation to the "moving-line theory"; the part played by the motional intensity.

Discussion of experimental results heretofore obtained.—Recent experiments upon the subject of unipolar induction are discussed in terms of the conclusions arrived at in the paper. One of the main conclusions reached is to the effect that, in *all experiments where a null effect was obtained, the nature of the apparatus was such as to shield off any effect which might legitimately have been expected.*

Calculation of effects for a rotating sphere.—The electrical field of a uniformly rotating, and uniformly magnetised sphere is calculated and discussed, under various conditions.

Magnetic doublet rotating about an axis passing through its centre and perpendicular to its own axis.—It is shown that the electric field may be calculated for this case from the "moving-line" law provided that the doublet is split into *two imaginary poles* and the lines for each are treated separately. It is necessary, however, to make the calculation on the basis that the *lines from the poles partake only of the linear velocity of the poles in their orbits*, and not of the rotational velocities about the centres of rotation. *In this form, the "moving-line" law is applicable to a magnetic doublet moving in any arbitrary manner* so long as the velocities are not comparable with that of light. AUTHOR.

1636. *Measurements of Penetrating Radiation at Kolberg.* **K. Kähler.** (Phys. Zeits. 21. pp. 324–327, June 15, 1920.)—The results of measurements of the penetrating radiation on the Baltic coast show that the radiation has a slight daily variation, and also a decided annual variation. As regards the daily variation, during the greater part of the year the radiation has somewhat higher values during the daytime. In the case of the annual variation, there is a max. value in late summer and a minimum value in late winter; the amplitude of the annual variation is, however, about three times smaller than in Freiburg (Switzerland), and just as small as found by Hess and Kofler on the Obir [Abs. 274 (1918)]. As regards meteorological effects, the increased values for the penetrating radiation in rainy weather are probably an effect of large variations of atmospheric pressure. A. W.

1637. *Electrification of Mercury by Contact with Insulators.* **E. Perucca.** (Accad. Sci. Torino, Atti, 55. pp. 278–292, 1919–1920.)—The discrepant results of previous investigations can be reconciled by noting that fresh surfaces of mercury become strongly charged positively; that under the influence of the air this property fades away, passes through a zero value, after which the charge produced is negative and, as time goes on, asymptotically approaches a maximum negative value. The cause of this phenomenon is to form the subject of a further paper. A. D.

DISCHARGE AND OSCILLATIONS.

1638. *Existence of Homogeneous Groups of Large Ions.* **O. Blackwood.** (Phys. Rev. 16. pp. 85–101, Aug., 1920.)—*Non-existence of groups.*—Certain observers have found evidence indicating that the large ions produced by spraying water constitute several distinct groups, each having a definite mobility. Using an apparatus similar to theirs, the author fails to confirm this result but finds that the ions distribute themselves continuously over a wide range with all intermediate mobilities present. In other words, he finds a *continuous* spectrum of mobilities and not a *band* spectrum. Conclusive proof of this has been obtained by a series of mobility determinations made with a Zeleny tube having a "resolving power" twenty times as large as that of the apparatus mentioned above.

Age and mean mobility.—The mean mobility of the ions decreases with time after formation at a rate indicating that the rate of condensation of water-vapour on any ion is constant and independent of its size.

Growth of ions dependent upon the humidity of the air.—Having replaced the water sprayer by a red-hot Pt wire as a source of ionisation, it was possible to control the water vapour-density. Drying the air causes a decrease in the rate of growth of the ions.

Growth of ions probably due to condensation of water-vapour.—The experimental facts are explained by assuming that large ions grow by condensation of water-vapour on a nucleus. This assumption is consistent with the views as to the nature of the large ion held by Barus, Aitken, Thompson, and others. AUTHOR.

1639. *Nature of the Negative Carriers produced in Pure Hydrogen and Nitrogen by Photo-Electrons.* **L. B. Loeb.** (Nat. Acad. Sci., Proc. 6. pp. 435–441, July, 1920.)—As the result of an investigation of the cause of the abnormalities of the negative ions in air at low pressures, it was found that the results obtained could be explained quite satisfactorily on the basis of a theory proposed by Thomson [Abs. 1450 (1915)]. This assumes that the electron does not attach itself to a neutral molecule to generate a negative ion on its first impact, but that on the average it will have a chance of uniting in one out of *n* impacts with a given type of molecule, where *n* is a constant which is characteristic of the type of molecule considered. For air this constant was found to be in the neighbourhood of $2 \cdot 5 \times 10^5$. If the oxygen molecule is the molecule to which the negative electron attaches itself in air, a point of view for which there is some evidence, this means that in only one out of 5×10^4 encountesr with oxygen molecules does the electron succeed in attaching itself to a molecule to form a negative ion. It seemed of interest to see how nitrogen and hydrogen molecules behaved in respect to this theory and to determine *n* for them if possible. The method used for the investigation of this question was to measure the mobilities of the carriers generated as photo-electrons from one plate of a condenser, using the Rutherford alternating-current method. Both the nitrogen and hydrogen used were purified before passing to the brass case enclosing the condenser. The values of the mobility constant k obtained from the curves for air was 3·25 cm. per sec. The values of k in a mixture of 98·4 % hydrogen, 1·6 % oxygen, were 12·9 and 20·3 cm. per sec. respectively, for the two pressures 293 and 151 mm. Since the normal values of k in air and in hydrogen are of the order of 2 cm. per sec. and 7·5 cm. per sec., it is to be concluded that the carriers observed are chiefly ionic in character. With the purified gases the results were very different. The curves obtained were practically saturation curves, their intercept with the voltage axis lying very close to the origin and being nearly independent of the frequency of alternation. It is obvious that the carriers must in these two cases be entirely electronic, for the curves cut the voltage axis so close to the origin that the values of the mobility computed therefrom are greater than 750 cm. per sec. The conclusion to be drawn is that in pure nitrogen and hydrogen gas the electrons do not attach themselves to the molecules to form ions in any appreciable quantities. A. W.

1640. *An Apparent Photoelectric After-effect in Calcium. Influence of Gassing on the Photoelectric Effect in Metals.* **J. Elster** and **H. Geitel.** (Phys. Zeits. 21. pp. 361–367, July 15, 1920.)—A continuation of experiments carried out by the authors in 1912, 1913, and 1916 [see Abs. 1147 (1916)]. A description is now given of a series of measurements of the photoelectric current from calcium after removal of the exciting radiation. The phenomenon of " gassing " at the surface of metals when radiated is discussed. A. B. W.

1641. *Electrical Discharges from Pointed Conductors.* **J. Zeleny.** (Phys. Rev. 16. pp. 102–125, Aug., 1920.)—*Surface action in electrical discharges from points.*—The lag phenomena shown by the discharges from some points indicate a special surface action. Various possible surface actions are discussed and attention is centred upon an adhering layer of gas molecules. Further evidence is sought in discharges from points made of different materials.

Electrical discharges from water points. Surface electric intensities and stopping voltages.—Discharges from water points begin impulsively. The surface intensity during positive discharges is independent of the current and a simple relation exists between values of this intensity, point radii, and air pressures. Empirical relations are given connecting point radii and stopping voltages. The results are compared with those from similar metal points.

Dependence of critical fields upon the curvature of surfaces of points.—An explanation is given of the fact that the critical field required for the production of a discharge is larger the smaller the radius of the point. The dependence of the field at the surface of a point during a discharge upon the divergence of the field is shown experimentally.

Discharge currents for points made of different materials.—Testing for a possible ejection of ions from a surface by impact, similar points of platinum, brass, copper, and water under the same conditions gave the same currents except that the negative current from water was slightly smaller than from the other substances. AUTHOR.

1642. *Visible Blue-Green " Brennfleckstrahlung " in the Lilienfeld X-ray Tube.* **J. E. Lilienfeld** and **F. Rother.** (Phys. Zeits. 21. pp. 249–

256, May 15, 1920.)—An investigation of the "Brennfleckstrahlung" (focal-spot radiation) observed in the Lilienfeld X-ray tube is now described. The investigation is divided into two parts, the first dealing with the condition of polarisation of the blue-green light emitted from the tube, whilst the second part deals with the spectrum of this light. Photographic reproductions are given in illustration.

In the later paper the authors correct certain observations relating to the polarisation investigation.

Erratum (*Ibid.*, p. 360, July 1, 1920). A. B. W.

1643. *Pressure upon Poles of Metallic and Composite Arcs. Reactions consequent upon Electron Emission.* **W. G. Duffield, T. H. Burnham, A. H. Davis.** (Roy. Soc. Proc. 97. pp. 326–348, June 1, 1920.)—Experiments upon the pressure on the poles of a carbon arc [Abs. 606 (1920)] led to a tentative theory that it was due to the recoil consequent upon the projection of electrons from the poles. Here the work is extended to metallic arcs, using poles of iron, silver, copper, an alloy of silver and copper, and a composite arc, one pole of silver and the other of carbon. The methods used are those previously described. For the results obtained and the detailed discussion based upon them the original paper should be consulted. The balance of evidence favours electronic projection from the kathode as responsible for the recoil usually observed. T. H.

1644. *Velocity of Propagation of Electromagnetic Waves.* **J. Wallot.** (Ann. d. Physik, 62. 6. pp. 569–572, July 16, 1920.)—In a former article [see Abs. 430 (1920)] the author dealt with the passage of electromagnetic waves through a layer, the dielectric constant of which was supposed to vary in a continuous manner according to well-defined laws, and found that the velocity of propagation of the energy V was related to the mean velocities of propagation of the electric and magnetic waves, $v_{el.}$ and $v_{magn.}$, by the relation $1/V=1/2[1/v_{el.} + 1/v_{magn.}]$. In the present article the author demonstrates that this formula is valuable for linearly polarised plane electromagnetic waves, not only in the case of the special hypothesis made in the preceding article, but in the general case, and for elliptically polarised plane waves when the electric and magnetic waves are polarised at right angles one to another. E. B.

1645. *Theory of Linear-Sinoidal Oscillations.* **H. G. Cordes.** (Phys. Rev. 16. pp. 179–201, Sept., 1920.)—*Constant-frequency arc discharges: theory assuming d.c. supply and arc potential drop to remain constant.*—A vacuum arc is shunted with inductance, capacitance, and resistance in series which constitutes a discharge circuit. The arc is supplied with direct current through a large inductance. The arc vapour is ionised and de-ionised at a constant frequency. The variations of potential and current in the discharge circuit are termed *linear-sinoidal oscillations*. Mathematical expressions are derived for the following quantities in terms of the *priming angle* and *damping angle*, namely: the logarithmic decrement, ratio of natural frequency to discharge frequency, *impedance factor* and ratio of the effective discharge circuit current to the direct current. These quantities are expressed in terms of transcendental functions of the angles, hence relations between them are determined by means of a chart and a table. Expressions for potentials at the instants of priming (critical ionisation) and unpriming are given. The relation between the values of the direct current and effective currents through the arc and in the discharge circuit is established. The actual fluctuation of the d.c. supply is approximately determined. The counter e.m.f. of an oscillator having a coupled secondary oscillatory circuit varies in a manner similar to the counter e.m.f. of a motor.

De-ionisation of arc vapour ; experimental determination of the rate.—An arc is extinguished by means of initiating a series of linear-sinoidal oscillations of decreasing frequency. The values of the priming angle, ratio of frequencies, discharge frequency, unprimed interval, re-ignition potential, and other quantities are approximately determined for the initial oscillations. An expression for the numerical value of the rate of de-ionisation is given.

Stability of an arc oscillator.—The value of series resistance to produce stability depends upon discharge circuit resistance, rate of de-ionisation, and rate of change of the rate of de-ionisation. Auxiliary means to produce a constant discharge frequency are required to stabilise an efficient arc oscillator for wireless signalling. AUTHOR.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1646. *Illumination and Conductivity of Selenium.*—**A. O. Rankine.** (Phil. Mag. 39. pp. 482–488, May, 1920.)—The author endeavours to discover the law of light-action for illuminations between 0·4 and 200 candle-metres. He determines the extra current due to light as soon as the current attains a steady value. He finds that the square-root law found by Fournier d'Albe (1913) for illuminations below 0·01 candle-metre does not hold good for these brighter illuminations, but that the extra current is proportional to the fourth root of the illumination, *i.e.*, to the square root of the amplitude. This suggests that light in reality exercises a "trigger" action rather than an ordinary ionisation. E. E. F.

1647. *Piezoelectric Effect in Rochelle Salt.* **A. M. L. Nicolson.** (Am. I.E.E., Proc. 38. pp. 1315–1333, Nov., 1919. El. World, 75. p. 1358, June 12, 1920.)—Experiments conducted in the research laboratories of the American Telegraph and the Western Electric Companies showed that Rochelle salt was susceptible of a greatly increased piezoelectric activity. This increased efficiency was brought about by desiccation, static compression, the application of torque, and a suitable choice of growth and poles. Analysis of the direction of applied stresses to the sensitive regions showed that, for the composite structure, a twisting couple about the principle axis excites the greatest potentials between the crystal electrodes. Applications are discussed, in particular the use of such a crystal as a phonograph transmitter. E. E. F.

1648. *Electrical Conductivity of Copper fused with Mica.* **A. L. Williams** and **J. C. McLennan.** (Phil. Mag. 40. pp. 281–290, Sept., 1920.)—Experiments made in 1919 at Cambridge showed that samples of copper when fused with mica exhibited a remarkably large fall in resistance when gradually subjected to rising temperatures. The samples used were prepared in the open on a piece of iron or copper plate—used as an anode—with a carbon rod as the kathode, the arc being struck at first between the plate and carbon, and then when hot between the plate and the mixture. The mica was first melted, then the copper added, about equal amounts of the two substances being taken. Resistance was measured at different temperatures from 27° to 850° C. In one sample (curves are given in the paper) the resistance fell from 16,000 ohms at 27° C. to 0·5 ohm at 850° C.

At 2000° C. the material was found to be malleable. On measuring the specific resistance by means of tests on a small rod of the substance it was found to be 10,400 ohms at 25° C. and 8000 ohms at 30° C. A film of the material was squeezed to about 0·001 in. thickness between Pt foil and this arrangement was found to be extremely sensitive to heat, responding to the action of infra-red rays from an arc about one yard away.

Further experiments have been carried out in the University of Toronto by Miss Isabel Mackey and Miss I. Giles under the superintendence of J. C. McLennan. Miss Mackey tested two different samples of Cu and mica in an electric furnace for resistance changes with temperature. In case No. 1 the resistance varied from 4400 ohms to 300 ohms while the temperature was raised from 25° to 400°. The density of this specimen was 5·1; as the density of Cu is 8·9 a considerable proportion of mica was present. In case No. 2 the resistance changed from 95,000 ohms to 3000 ohms while the temperature was raised from 100° C. to 400° C; the density of the material was 4·3. Two mixtures of iron and mica were made, and on testing these it was found that in case No. 1 the resistance fell from 1300 to 100 ohms on heating from 25° C. to about 300° C. In case No. 2 the resistance fell from 32,000 ohms to about 1300 ohms as the temperature rose from 160° C. to 380° C. The hardness resembled that of glass and the material was much more brittle than copper-mica and had more metallic lustre. Experiments were made with Al, Sb, Bi, Co, Ni, and Mn mixed with mica with varying results. A graph is given for the changes in resistance with temperature for Se and Cu fused together. A discontinuity which is unexplained occurred in this case at about 150° C. With commercial ferro-silicon the resistance was found to vary directly as the temperature, as in the case of ordinary pure metals. The graph is a straight line.

In experiments by Miss Giles a micrographic study was made of the plane polished surfaces of the fused copper-mica mixtures both at room temperatures and when the temperature was gradually raised. The object was to find if the fused mixtures possessed any crystalline structure, and if so whether the increased conductivity was connected in any way with observable modifications in the crystal structure. The samples, however, when examined appeared to be quite uniform in structure, and in some there seemed to be globules of pure Cu. In general no change in structure on heating was observed. J. J. S.

1649. *Physical Properties of Nickel-Iron Alloys.* **L. R. Ingersoll.** (Phys. Rev. 16. pp. 126–132, Aug., 1920.)—*The specific heats, thermal conductivities, thermoelectric powers, and resistivities* have been determined for a series of *iron-nickel alloys* of exceptional purity and definitely known composition.

The *specific heat* (25° to 100° C.) varies only slightly with change in composition, but gives, nevertheless, a well-defined maximum at 35 % Ni. The *thermal conductivity* (20° to 100° C.), on the other hand, shows a much larger variation, with a value for 35 % Ni of only one-fifth of that for either pure iron or pure nickel. The *thermoelectric power* (0° to 96° C.) against copper exhibits a marked minimum at 35 % Ni with maxima at about 20 % and 50 %. The *resistivity* at 0° C. shows a marked maximum at 35 % Ni, more than five times the value for either pure iron or pure nickel. The relative increase is not so great as the temperature is raised to 700° C. The temperature coefficient of resistance, considering the whole range (0° to 700° C.) is a minimum for the 35 % Ni. These facts are in general agreement with the anomalies in other properties shown by Ni-Fe or nickel-steel of this composition and point to the formation of the definite compound Fe_2Ni. AUTHOR.

1650. *Contact Detectors.* **R. Dongier.** (Comptes Rendus, 171. pp. 238–240, July 26, 1920.)—Using a point-crystal (galena) or point-metal contact detector, the point being attached to the diaphragm of a phonograph reproducer, a sort of telephone was constructed which was found to reproduce speech with great clearness when the arrangement was used as an auto-detector in a wireless telephone set. The effect in question has been investigated by other experimenters [Abs. 1197, 1199, and 1200 (1920)]. A. W.

1651. *Amplification of Electric Currents in the Bunsen Flame.* **C. W. Heaps.** (Phys. Rev. 16. pp. 238–246, Sept., 1920.)—The subject is dealt with on the lines now usual in dealing with electronic valves, but the work of de Forest is not mentioned. L. H. W.

1652. *Correction of Contact P.D. developed in Compton's Electrometer.* **O. Stuhlman, Jr.** (Phys. Rev. 16. pp. 158–161, Aug., 1920.)—A method of eliminating contact difference of potential in Compton's modification of the quadrant electrometer is suggested. The quadrants must not be built up. Solder, fillers, or finishers must be omitted. If the needle is of Al the quadrants must be of Al, milled out of a single piece of metal. The final curve shows the absence of contact p.d. in such an instrument when reconstructed and possessing an Al needle and milled Al quadrants. AUTHOR.

1653. *Theory of the Katharometer.* **H. A. Daynes.** (Roy. Soc., Proc. 97. pp. 273-286, June 1, 1920.)—Gives the theory of the instrument, which is of the form of a hydrogen detector based upon the increase in heat conduction of a gas or mixture due to the presence of hydrogen. A Wheatstone bridge method is employed for the detection of the change in conductivity. L. H. W.

1654. *The Vertical-Intensity Variometer.* **G. Hartnell.** (Terrest. Magnetism, 24. pp. 49–64, June, 1919.)—Discusses some of the characteristic features of the Z- or vertical-intensity variometer, the theory of the instrument and the action of the knife-edge support being particularly considered. L. H. W.

1655. *The Optophone.* (Electrician, 85. pp. 183–184, Aug. 13, 1920.)—A description of the constructional features of the apparatus as now manufactured by the firm of Barr and Stroud. [See Abs. 964 (1913) and 337 (1914).]

ALTERNATING CURRENTS AND MAGNETISM.

1656. *Note on Theory of the Magnetometer.* **L. Srivastava.** (Calcutta Math. Soc., J. 11. pp. 35–42, Sept., 1920.)—Starting with the bar magnet in the Gauss A-position, or magnet to east or west of needle, the actual distances of the poles of the deflected needle from those of the deflecting magnet are taken into account in equating the moments of the deflecting and restoring forces. By employing suitable transformations, an expression for the deflecting couple is obtained which can be expanded in terms of Legendre's coefficients. The final form contains these in the form $dP_1/d\theta$, $dP_3/d\theta$, etc., where P_1, P_3 are the coefficients and θ is the angle of deflection of the needle. If only the terms containing P_1 are taken, the usual magnetometer formula is derived. The condition that $dP_3/d\theta$ shall be zero involves that $\sin\theta = 1/5$, or that θ should be 26½°. Working out the case for the B-position in a similar way, it is shown that the best value of θ to employ is 31°. G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1657. *Notes on the Electro-Cardiograph.* **R. S. Whipple.** (Inst. El. Eng., J. 57. pp. 13–26; Disc., 26–28, April, 1920. Supplement. Abstracts in: El. Rev. 84. pp. 360–361, March 28, 1919. Electrician, 82. pp. 372–374; Disc., 374, April 4, 1919.)—This paper is mainly concerned with details of the string galvanometer, the connections employed and the technique of electro-cardiography. A table of sensitivities and resistances of a number of string galvanometers of the Cambridge pattern is given and here reproduced as being of general interest. For further details the original should be referred to.

Material of Fibre.	Diameter.	Resistance.	Period.	Deflection in mm. per Micro-amp.	1 mm. Deflection produced by
	mm.	Ohms.	Second.	mm.	Micro-amps.
Silvered glass	0·003	8720	0·004	7·3	0·137
"	0·002	6610	—†	68,400	0·000015
"	0·0035	3060	—†	48,000	0·000021
			0·005	13·2	0·076
"	0·0025	12,030	—†	67,000	0·000015
"	0·0025*	4000*	—	40*	0·025
Aluminium wire	0·035	6·9	0·039	13·2	0·076
			0·0012	0·013	76
Silver wire	0·017	8·2	0·082	43	0·023
			0·0026	0·048	21
Platinum-silver wire.	0·012	230	0·021	4	0·25
Copper wire	0·015	6·3	0·016	2·5	0·4

* These values correspond to the values used for cardiographic work.

† In this case the movement of the fibre was quite dead-beat; it took about 10 seconds to attain its full deflection. Magnification in all cases 600 diameters.

L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1658. *Separation of the Isotopes of Mercury.* **J. N. Brönsted, G. Hevesy.** (Nature, 106. p. 144, Sept. 30, 1920.)—The authors have been successful in achieving a partial separation of the isotopes of mercury by evaporating mercury at low pressure and condensing the evaporated atoms on a cooled surface. The rate of evaporation of the isotopes being inversely proportional to the square root of their atomic weight, and practically every atom leaving the liquid being condensed on the highly cooled surface, a partial separation of the isotopes of mercury was to be expected.

By using the pyknometer method the following numbers have been obtained in one set of experiments for the density of the condensed, and in another set for that of the residual, mercury, when taking the density of ordinary mercury as unity: Condensed mercury, 0·999980; residual mercury, 1·000031.

The apparatus contained 40 cm.^{3} of mercury. In the first set of experiments about 1/7 of the mercury was evaporated and the density of the condensed part determined; in the second set about ¾ of the mercury was evaporated and the residual portion examined. After the separation every portion was distilled again several times in the ordinary way and the density measured after each distillation. No difference was found between these measurements, the error of measurement of density being less than one in a million. AUTHORS.

1659. *Charcoal Activation.* **H. H. Sheldon.** (Phys. Rev. 16. pp. 165–173, Sept., 1920.)—*Adsorption of gases by charcoal; heat effect.*—The first part of this paper comprises a study of the heat effect on the adsorption of hydrogen and nitrogen by charcoal, and is a continuation of the work of H. B. Lemon in which air was used. The charcoal is heated for periods varying from 1 to 20 hours at temperatures from 400° to 1000° C., and at the same time the gases given off are pumped out with a mercury condensation pump. The activity of the charcoal is tested after each treatment by its adsorption of gas at liquid-air temperature, and the results are shown by curves where log. of time in minutes is plotted against log. of pressure in cm. The agreement with predictions from the hydrocarbon theory of adsorption is pointed out. That activation takes place by slow oxidation at room temperature is also shown.

A new form of charcoa ; selective adsorption.—By heating to 1000° C. for 3¼ hours, a sample of charcoal was put into a condition such that it adsorbed hydrogen more readily than nitrogen. Theory is advanced to account for this. AUTHOR.

1660. *Sources of Helium in the British Empire.* **J. C. McLennan, J. Satterly, E. F. Burton, H. F. Dawes, J. Patterson, H. A. McTaggart,** and **R. T. Elworthy.** (Dept. of Mines, Canada, Bull. No. 31. pp. 1–72, 1920.)—This is a report on the search for helium in natural gas, conducted at the instigation of the Board of Inventions and Research with the support of the Admiralty, etc., since 1915. The report deals in detail with the helium contents of the gas in Canada, in the Provinces of Ontario, Alberta, British Columbia, and New Brunswick, and also in New Zealand, in the United Kingdom, and elsewhere. In Canada the helium percentage is greater (maximum 0·36 in Alberta) in the Western parts than in the East. The methods of determination (by combustion or condensation, spectroscopic and radio-active tests, gas density balance) are described. References are made to the helium production plant at Calgary, where finally a helium of 97 % was obtained, and to the uses of helium. H. B.

1661. *Colloidal Selenium.* **J. Meyer.** (Zeits. Elektrochem. 25. pp. 80–82, March 1, 1919.)—Colloidal selenium is very suitable for the study of colloids, as the solutions are stable and coloured, and it is best prepared, analogously to sulphur, by the reaction $Na_2SeSO_3 + H_2SO_4 = Se + SO_2 + Na_2SO_4 + H_2O$. Sodium sulphite is dissolved in water and boiled for less than a minute with selenium, the solution is filtered and diluted, sulphuric acid is added, and the solution then filtered through a Zsigmondy membrane to yield a clear sol, the particles of which are electro-positive, whilst the selenium solutions in alkaline hydrazine hydrate are electro-negative. When two such solutions are mixed, precipitation does not take place, however, because hydrazine sulphite is also formed which dissolves the selenium; the solutions must hence be dialysed before mixing. H. B.

1662. *The Action of Metallurgical Additions on the Dilatation of the Nickel Steels.* **C. E. Guillaume.** (Comptes Rendus, 170. pp. 1433–1435, June 14, 1920.)—Manganese, which is necessary to render the alloy forgeable, may be present up to 8 %, when the material casts well. Carbon may be present from 0·1–0·6 %, the higher contents raising the elastic limit. Chromium has a similar effect, but above 10 % the alloy is difficult to forge. Tungsten and vanadium may also exert an influence. The nickel content of the "invar" at which the minimum dilatation is found is increased 4·7 % by 8 % of Mn, 0·8 % by 8 % Cr, and lowered 2 % by 5 % of Cu, and 3 % by 0·6 % of carbon. The effect of all these additions is to increase the minimum dilatation, the influence of carbon being specially noteworthy. F. C. T.

1663. *Influence of Ions on Osmotic Pressure of Solutions.* **J. Loeb.** (Nat. Acad. Sci., Proc. 6. pp. 211–217, April, 1920.)—Gelatine is an amphoteric electrolyte, the hydrogen-concentration at which it is in combination neither with acids nor with bases being $10^{-4\cdot7}$ N or $p_H = 4\cdot7$. The osmotic pressure can be measured in collodion bags, which are permeable to water but not to gelatine. The influence of ions on the osmotic pressure of gelatine solutions is as follows: 1 % solutions of gelatine salts in the acids have the highest osmotic pressure when $p_H = 3\cdot4$ and this is between two and three times as great when the acid is univalent as when sulphuric acid is used, whilst metallic gelatinates have their highest osmotic pressure when $p_H = 8\cdot4$, and this is between two and three times as great when the metal is univalent as when it is bivalent. In the former case the osmotic pressure is lowered by the addition of neutral salts or acids, and in the latter case by neutral salts or alkalies, and these effects increase with the valency of the anion and kation respectively. T. M. L.

1664. *Heat Treatment of High-Chromium Steel.* **H. J. French** and **Y. Yamauchi.** (Chem. and Met. Eng. 23. pp. 13–16, July 7, 1920.)—Gives the results of experimental work on the heat treatment of a high-chromium stainless steel containing 13 % Cr and 0·3 % carbon. Etching, for microexamination, was carried out by means of a solution consisting of 2 parts concentrated nitric acid, 1 part concentrated hydrochloric acid and 3 parts water. The samples, quenched in oil from various temperatures, show that with increasing quenching temperature the hardness increases until a temperature of 1066° C. is reached. Maximum hardness is generally obtained from this to the highest temperature used (1230° C.). Quenching from 955° C. develops the best combination of strength and ductility, but does not retain all the carbide in solid solution. Ductility is very low in the samples quenched from 1000° C. or above. Short-time tempering at temperatures up to 430° C. of samples previously quenched at about 1000° decreases brittleness. Tempering above 430° C. decreases strength values and hardness and greatly increases ductility. The most rapid change in tensile properties and hardness occurs in tempering between 430° and 540° C. C. O. B.

1665. *Photographing Etched Sections at Low Magnifications.* **J. H. G. Monypenny.** (Chem. and Met. Eng. 22. pp. 882–883, May 12, 1920.)—For magnifications up to 4 diams. a camera is used with a 5¼-in. anastigmat lens and long extension. The illumination from a projection lantern is focused on a ground-glass plate placed quite close up to the section, an area of uniform illumination much bigger than the section being produced. For higher magnifications, 9–25 diams., a Zeiss 35-mm. projection lens is employed. This is attached to the microscope with a wide body, the inner draw tubes being removed. The illuminant is a 500-c.p. Pointolite lamp. A condenser forms a considerably enlarged image focused close up to a second condenser. The latter, after reflection at a 45° cover-glass reflector and the specimen, focuses the image on the lens. The condensers used are 2⅛ in. diam. and 2¼ in. focal length and a uniformly illuminated field 1 in. in diam. is produced. As a reflector, thin lantern slides are used for the lowest powers and a microscope cover-glass 1⅞ × 1¼ in. in a light metal frame for the somewhat higher ones. Very excellent micrographs are shown. F. C. T.

1666. *The Conductivity of Dilute Alloys Free from Mixed Crystals.* **K. Lichtenecker.** (Phys. Zeits. 21. pp. 352–354, July 1, 1920.)—Burger has recently carried out experiments to determine the conductivity of alloys free from mixed crystals [Abs. 812 (1919)]. He limited these to dilute alloys in which the volume of one of the two components was only a very small fraction of the total volume. With this limitation, Burger made an approximate calculation for the conductivity of a dilute alloy in which the lower component is sprinkled throughout the volume in the form of small isolated particles of simple shape (spheres, rods, plates). The object of Burger's work was to find whether the shape of the boundary between the components of the alloy exerts an influence on the value of the specific conductivity. Burger concluded that such was the case.

The present paper is a criticism of this work, whereby the author establishes that Burger's formula leads to impossible values for the conductivity in certain cases. Section A deals with the case of non-conducting material embedded in a conductor, and Section B with conducting material enclosed in a non-conducting medium. In case A for plates and in B for plates and rods, impossible values are obtained with Burger's formula. Only in the case where the particles have spherical shape is the formula valid, and this problem has been already solved by Maxwell. The latter's work is then briefly described, and the paper concludes with a reference to the satisfactory results obtained on the assumption of a tesseral space-lattice arrangement. H. H. Ho.

1667. *Anomalous Osmose of some Solutions of Electrolytes with Gold-beater's Skin Membranes.* **F. E. Bartell and O. E. Madison.** (Journ. Phys. Chem. 24. pp. 444–465, June, 1920.)—In the osmosis of electrolytes through diaphragms, the two operative factors whereby the electrical condition disturbs the normal osmotic relation are (1) the electrical double layer depending on the extent of selective ion adsorption which is formed between the capillary pore wall and the liquid bathing this wall, and (2) the electrical potential existing between the two faces of the membrane through the different diffusion rates of anion and kation. The normal osmotic effect is defined as the process tending to produce an equilibrium difference of pressure as formulated by the gas law when solution and solvent are separated by a membrane permeable to the solvent alone. Abnormally high positive osmose exists when the sign of the charge on the membrane, through selective adsorption, is the same as that which through selective ionic diffusion is set up on the solution side relatively to the solvent side. Conversely, when the potential imparted to the membrane is of the same sign as that of the solvent relatively to the solution, an abnormally low or even negative osmose may exist. With negative osmose, a flow of solute takes place through the diaphragm from the more concentrated to the more dilute side.

Measurements were made with a membrane of gold-beater's skin of the osmotic effects with a number of solutions and, by means of calomel electrodes placed in the solutions on either side of the membrane and using the compensation method, of the p.d. associated with the same cell system. As the theoretical max. osmotic pressure cannot be approached with these membranes through their not being semi-permeable, comparative measurements were made of the rates of flow of liquid through the diaphragm. The values obtained with sugar solutions of the same concentration were taken as the normal or standard values.

Solutions of salts of univalent and divalent kations give an osmotic rate lower than the normal, the superimposed electrical effect thus working in opposition to the normal osmosis. With salts of Al and Tl the electrical effect works in conjunction with the normal osmosis to give an abnormally high value for the osmosis. In the case of both sodium hydroxide and nitric acid, the osmosis is positive at concentrations below about 0·01 N and negative at higher concentrations. Increase in concentration causes but slight increase in the osmosis of solutions of univalent kations, a marked increase in those of divalent kations and a greater increase in those of trivalent and quadrivalent kations. This effect is attributed to the changes produced by the concentration of the solutions on the charge of the membrane against the solution, the electro-negative charge leading to low osmotic values and electro-positive to high values.

The potential on the solution side is always positive in relation to the water side with all electrolytes measured except nitric acid, in which case the potential is positive on the water side. The positive potentials increase with increasing valencies of the kations. J. N. P.

1668. *Investigation of Metals by Means of X-Rays.* **F. Janus and M. Reppchen.** (Faraday Soc., Trans. 15. Appendix pp. 3–44, Feb., 1920. From the German.)

1669. *Principles governing the Penetration of Metals by X-Rays.* **G. Respondek.** (Faraday Soc., Trans. 15. Appendix pp. 45–64, Feb., 1920. From the German.)